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SCIENCE FACTS YOU WON'T BELIEVE

WILLIAM P. GOTTLIEB

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FOR HERMAN AND NINA SCHNEIDER,
whose science books have set
standards for precision and style

False facts are highly injurious
to the progress of science, for they
often endure long; but false views,
if supported by some evidence,
do little harm, for everyone takes
a salutary pleasure in proving
their falseness: and when this is
done, one path towards error is
closed and the road to truth is
often at the same time opened.

Charles Darwin
The Descent of Man

Science Facts You Won't Believe

Introduction

Why are astronauts weightless in outer space?

Because they escape gravity.

That makes sense. Anyway, it's what we usually read in newspapers and hear on TV. And it's what many of us have learned in school.

You may not believe it, but that explanation happens to be false! Astronauts never escape gravity. They become weightless for another reason. We'll find out later in this book just how they become weightless. But for now, let's briefly consider a few of the other false "facts" that will subsequently be described in detail:

- Almost every one of us has learned that the primary colors—those basic colors with which all other colors can be made—are red, yellow, and blue. Actually, the true primary colors are red, *green*, and blue (when mixing light) and magenta, cyan, and yellow (when mixing pigments).

• Snow falls heavily around the South Pole—*or* does it? In truth, the South Pole region receives *less* snowfall than any area of equal size in the northern part of the United States.

• The moon travels around the earth. That's supposed to be an established fact. However, to an observer located far out in space viewing what actually happens, the moon would not appear to be circling the earth at all.

• Does a rocket get its push from the jet of gases that whoosh from its nozzle? No, not really, though that's what we're usually told. It's more accurate to say that the rocket moves because the escaping gas is *not* pushing.

• Is your heart on your left side? No. Do you breathe with your nose? No. Do you have just five senses? Again, no.

• Did Columbus prove the world was round? Does the moon have a dark side? Is the sun responsible for our seasons? Have you ever seen the solar system drawn to scale? No. No. No. And no.

Wherever we turn, we can find sense diluted with nonsense, fact distorted by fancy. Misconceptions exist in every area of knowledge; however, for practical reasons this book is limited to matters of science and to subjects closely related to it. Many of the revelations in these pages are just for fun: ostriches do *not* hide their heads in sand; a compass does *not* point to the North Pole; Grade A eggs are *not* bigger or more nutritious than Grade B's. Revelations like these are startling, and would that there were enough pages to include a hundred of them. As much as possible, however, the emphasis here is on the kind of misconceptions that, when exposed, reveal important scientific concepts.

It is hoped that this book, by exposing some fallacies, will shock you into taking a more probing, inquisitive look at your surroundings. At least it should make you aware that

- folklore is often wrong
- seeing is not necessarily believing
- you should not always trust what you hear
- you can't always rely on common sense
- facts are not necessarily so, just because they're printed in a book....

Which also means that if you readily accept everything printed in *this* book, you're simply not getting the message!

1 Facts About Human Beings

Human beings! Now there's a subject we can feel close to. Yet close as we are, our knowledge about humans is often based on misinformation that's either given to us or is based on our own misguided faith in what *appears* to be true.

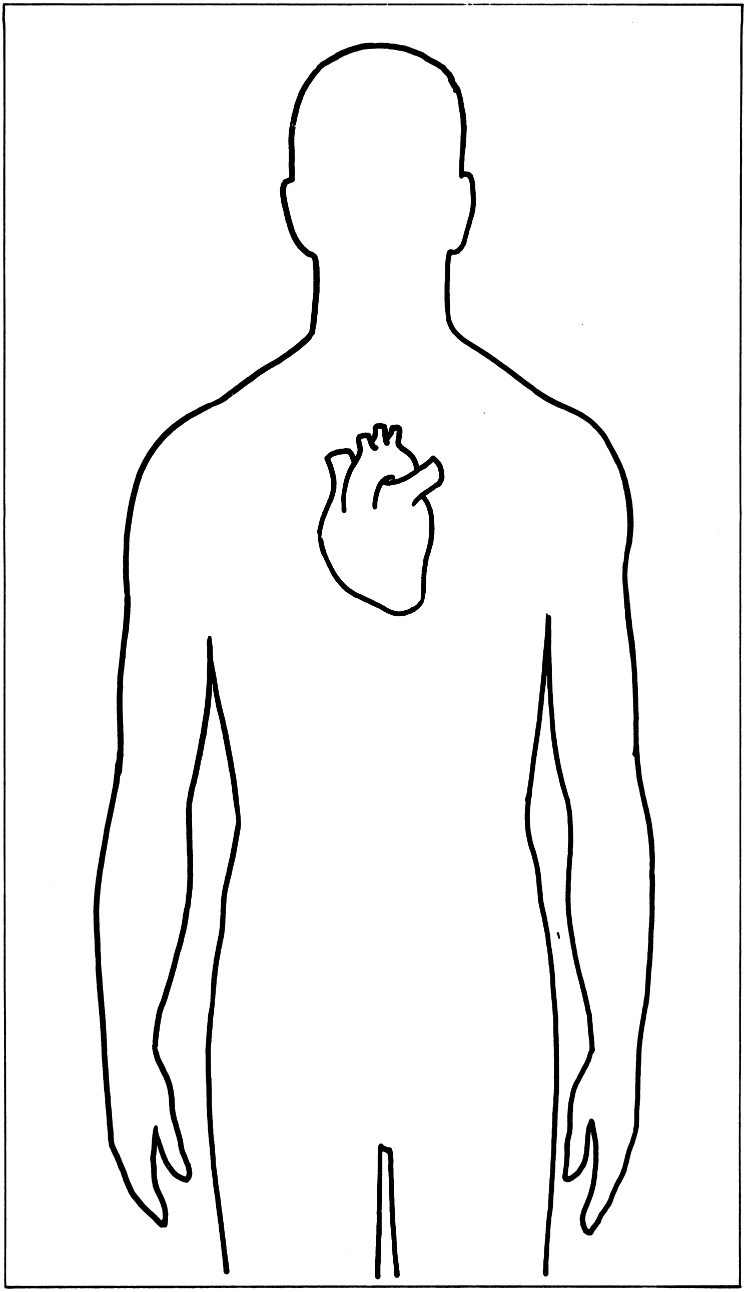
A HUMAN HEART IS
NOT ON THE LEFT SIDE
OF THE CHEST

The heart of the matter is this: in spite of popular folk wisdom, a human heart is not on the left side of the chest. It's almost in dead center, with the lowermost section—the apex—tilting slightly more toward the left than the right. (Figure 1.)

Other interesting facts about the heart:

Its shape only vaguely resembles the hearts on valentines.

A leaky heart valve does not cause blood to spill into the chest cavity. A heart valve is specially structured heart



[FIGURE 1]

tissue that is shut tight by the pressure of the blood against it, preventing the blood from flowing prematurely from one heart chamber to another. A leaky valve is one that doesn't shut tight, thus permitting some blood to flow into the adjacent chamber when it shouldn't.

WE DON'T BREATHE WITH OUR NOSES

Although breathing is something we do continuously, few of us realize which part of our body is most responsible for performing this vital function. Most of us think it is our nose. We tend to think of our nostrils as little pumps, pulling in air and forcing it down a windpipe to our lungs, causing the lungs to expand, which in turn expands our chests.

Not so. Breathing works the other way around.

Inhaling begins with our chest muscles, particularly the *diaphragm,* a muscular membrane that runs across the bottom of the chest. Without having to think about it, our brain automatically causes these muscles to expand, thereby enlarging the chest and creating a partially empty cavity—a semivacuum.

It happens that our breathing takes place near the earth's surface, at the lower part of an atmosphere that's about 100 miles (160 km) thick. This lower air is compressed by the weight of the rest of the air pressing down from above. (At sea level the air presses with a force of nearly 15 pounds [6.7 kg] per square inch [6.5 sq. cm].) The instant a cavity appears in the chest, the compressed air forces its way through the nose (or mouth), down the windpipe, and into the lungs, which then expand to fill the cavity. The nose's role? It serves principally as a passive opening through which the compressed air can enter. When we exhale, the chest muscles contract, squeezing the air from the lungs and sending it out through the nose, which again serves only as a passageway.

Here's a demonstration to help you visualize how the breathing process works:

A glass bottle whose bottom has been cut off represents a chest cavity. The bottom half of a large balloon, attached tightly to the bottle with rubber bands, becomes a diaphragm. A sturdy drinking straw, snugly inserted through a channel drilled in a tight-fitting cork, serves as a windpipe, with the upper end acting as a nose. Attached to the lower end is a small balloon—a lung. (Figure 2.)

When the diaphragm of this apparatus is expanded—pulled outward—the size of the chest cavity is thereby increased, forming a partially empty space. Instantly, atmospheric pressure forces outside air through the nose, down the windpipe, and into the lung, which expands to fill the empty space.

The apparatus has "inhaled." (Figure 3.)

When the diaphragm is then pushed inward, it contracts the size of the chest cavity. This compresses the air inside the cavity, which squeezes the lung, causing it to expel the air it had previously inhaled.

The apparatus has "exhaled." (Figure 4.)

By alternately pulling the diaphragm out and then pushing it in, you can keep the apparatus breathing. And as should be evident, the work is done by the diaphragm in conjunction with atmospheric pressure. The nose? It's just a passageway.

WET FEET DON'T CAUSE HEAD COLDS

We have all been told to keep our feet dry because "wet feet cause head colds." The Harvard Medical School assures us this isn't so. Getting chilled doesn't bring on colds, either. Only viruses can do that, and they can cause colds even when our feet are dry and our bodies are warm. Scientists working at the frigid South Pole often go for

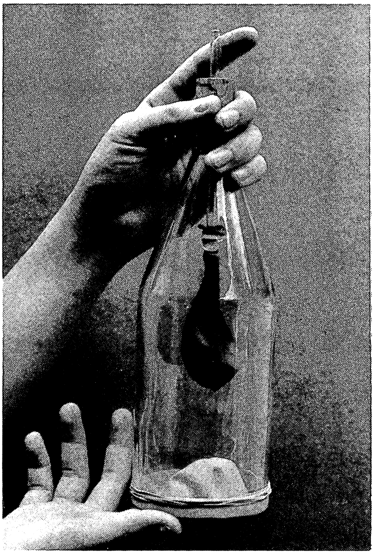


FIGURE 2

FIGURE 3

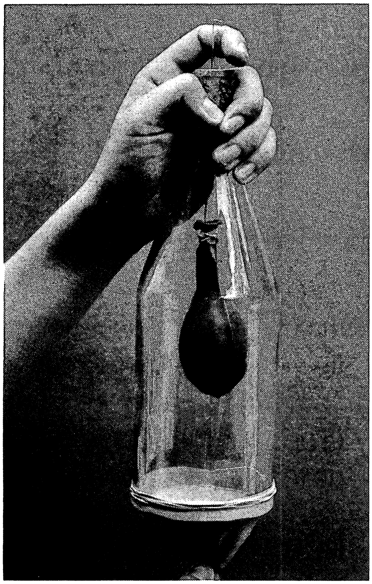


FIGURE 4

months without a sneeze. But if visitors show up and one of them bears cold germs, colds then break out.

A doctor, August A. Thomen, wrote a book, *Don't Believe It!,* that dispelled many myths about our bodies and our health. Here are some examples:

No one is double jointed; instead, people who have joints that bend in extraordinary ways simply have bones that are held together by permanently stretched ligaments.

We don't get sick from eating green apples.

Nobody's hair has ever turned gray overnight from fright or for any other reason (except, perhaps, from a bottle of hair coloring).

A compound fracture is not a fracture with more than one break; it's a fracture in which the bone has broken through the skin.

Hay fever is not caused by goldenrod. It is mostly caused by ragweed, which propagates by the dispersal of its pollen by the wind. It's this wind-borne pollen that gets into noses and causes trouble. Goldenrod's conspicuous flowers and ragweed's inconspicuous pollen mature at the same time and in the same habitats, hence the confusion. (The fact that goldenrod bears flowers indicates that its pollen is not carried by the wind but by bees.)

HUMANS HAVE MORE THAN FIVE SENSES

We all know about the five senses: sight, hearing, smell, taste, and touch. Sometimes we talk about a "sixth sense" possessed by certain animals, and, perhaps, by some humans. Actually, all animals—including humans—have a sixth sense . . . and a seventh . . . and an eighth . . . and a lot more.

Two notable zoologists, Lorus J. and Margery Milne, attribute the myth of the five senses to the great philosopher of ancient times, Aristotle. His scientific conclusions were remarkable for his day, but many of them have proved to be as inaccurate as they have been long-lived.

Another zoologist, Maurice Burton, puts the issue this way: "It is not just a question of whether or not there is a sixth sense, but of just exactly how many additional senses there are."

All authorities agree that there is a sense of balance. The sense of balance is controlled by three semicircular canals, which are a part of the inner ear that has nothing to do with hearing. These canals contain fluid that works somewhat like the fluid in a carpenter's level. Sensitive hairs in the canals feel the smallest movement of the fluid. The three canals are arranged so that motion in any direction is immediately felt; this information is immediately transmitted to the brain, which then "instructs" the muscles to make the necessary adjustments to keep the body in balance.

Other senses often overlooked are those involving hunger and thirst. There is also a sense that keeps us informed as to where the different parts of our body are at any moment. (Even with our eyes closed, we can touch our noses with a finger on the first try.)

Scientists can't decide whether certain related functions should be counted as a single sense or as many: one set of nerves in our eyes can receive only dim light and sees objects in blacks, whites, and grays, while another set can see bright light, including colors. Should these two completely different sets of receptors be considered one sense or two?

The skin has separate nerves for touch, for pressure, for pain, and for heat: one sense or four? The tongue has separate taste buds for sweetness, saltiness, sourness, and bitterness: how many senses do they add up to?

There are also various nonhuman senses, such as those that make it possible for birds, butterflies, fish, and turtles to migrate thousands of miles each year with the accuracy of a master navigator. It could be that humans have at least the remnants of these extra senses. People who believe in extra sensory perception think this is so. Thus far, they have been unable to build a convincing scientific case to support their hypothesis. But, even without the senses associated with ESP, our bodies possess many senses whose existence is firmly established.

Five senses? Five times five makes more sense.

OUR SENSES DO NOT SEND ACTUAL SIGHTS AND SOUNDS INTO THE BRAIN

It is widely assumed that our senses send actual sights and sounds, as well as other impressions, into the brain. If, however, we could look inside a living brain while around us bright lights were shining and loud noises were booming, we'd see no light and hear no sound. All would be dark and quiet.

We are able to see an object if light waves coming from it pass into our eyes. The waves then strike nerves, triggering electrical impulses that travel along the nerves to the brain. The light waves themselves do not travel—just the electrical impulses. Think of a finger turning on a switch at the end of an electric wire; the finger doesn't travel along the wire—just the electricity. Somehow, by means not fully understood, the brain is able to decode the impulses it receives into the *idea* of an image so that we "see," say, a red bird.

Meanwhile, nerves in our ears are receiving different kinds of waves—sound waves—that trigger other nerve pulsations. The brain interprets them so that we hear the song the bird is singing, even as we see what it looks like. Yet the brain, where this all takes place, continues to be dark and quiet.

Incredible!

OUR SENSES ARE SEVERELY LIMITED

We take for granted that our senses give us an accurate idea of the world around us. We probably realize dogs can hear some sounds we can't, and hawks can see objects too far away for us to see; but, except for such special cases, those of us with normal sensory capabilities believe we behold our surroundings as they truly exist.

Actually, we perceive only a portion of reality. Although our sense organs are bombarded every moment with billions of stimuli, our brains comprehend only an infinitely small part of these stimuli.

Consider vision. We see because our eyes are capable of receiving some of the streams of energy, called electromagnetic waves, that reach us. The waves we can perceive—the visible waves—are only a fraction of the total range of electromagnetic waves. The rest—including gamma rays, X rays, ultraviolet rays, infrared rays, and radio waves—are invisible. Yet they are there, and they are real. We can even make use of them. With the help of special instruments, such as radios and X-ray machines, we can use invisible rays to gain impressions beyond the capacities of our unaided senses.

What about the sounds we hear? Sound waves are created when an object vibrates and causes surrounding substances, such as air, to vibrate with it in ever-spreading waves. When vibrating waves reach our ears, the vibrations are picked up and repeated by our eardrums. The message is then sent by nerves to our brains for interpretation, *if* the waves that reach us are within the range that our eardrums and brains are capable of receiving.

The reception range of an ear can differ slightly from individual to individual, and greatly from species to species. Dogs, whales, mice, fish, cats, and almost all nonhuman animals make sounds *we* can't hear, but *they* can. Certain bat sounds are actually louder than those of the jackhammers used for repairing roads; but fortunately, these shrieks are out of our range. The movement of our blood, the growing of plants, and every other kind of motion produces sound waves in the air. Suppose we could hear these and all the other vibrations that continually assault our ears. The noise would be shattering—too much for our brains to handle. We'd go crazy.

All of our senses are severely limited. Have you ever sharpened a knife on a spinning grindstone? The sparks really fly, and many land on your hand. The sparks are bits of burning steel. Yet you experience no pain because the sparks are so small that they have too little heat and weight to be felt.

But we can be hurt by things we can't see or feel. Think of the bad sunburns some of us have gotten from the sun's invisible ultraviolet rays.

So far, we've discussed only a few of the limitations of our senses. There are many more, concealing realities that are there, beneath our noses. What of the microscopic world that's revealed only through powerful magnifiers? It's nothing like the world we know, but it is just as substantial. And what of the submicroscopic world that physicists *know* is there, even though they can't see it: a world in which all substances are made of atoms, which in turn consist of electrons, protons, neutrons, and, most of all, empty space!

Despite their severe limitations, our senses are well-suited to our needs. Through millions of years of evolution, humans have developed senses that have helped us survive. We still can't see electrons, and we still can't hear grass grow. But almost from the beginning, we've been able to see a lion and hear it roar. And that's what counts.

THE THEORY OF EVOLUTION IS NOT WHAT MANY PEOPLE THINK IT IS

About 125 years ago, when Charles Darwin proposed his theory of evolution, he created a furor unequaled since the time, more than three hundred years earlier, when Copernicus announced that the earth travels around the sun.

The furor over evolution continues. Even among scientists who are firm believers in the theory, many are convinced that much of Darwin's version of evolution needs revision: that, for example, changes in species do not develop very slowly, as Darwin believed, but come, comparatively speaking, in spurts. But whatever the specifics may prove to be, the science community recognizes that the basic theory of evolution remains a monumental breakthrough in our understanding of how life develops.

Outside the science community, there is much confusion as to just what the theory of evolution says. We sometimes hear that the theory states that "humans are descended from monkeys." What the theory actually says is that humans and monkeys—and all animal life—are probably descended from common ancestors.

Another false notion holds that each successive step in the evolution of an organism results in an improvement, a superior form of life. Not so. What evolution *does* produce are plants and animals that are better adapted to a changed environment than are the living forms they replaced. Better adapted—not superior. Should the earth suddenly be blanketed by deadly radioactivity, the best survivors, if any, might be certain insects. Could you say that those insects were superior to the humans they replaced?

Evolution is not a tale of progress, explains Stephen Jay Gould, an authority on Darwinism; "... rather, it is a story of intricate branching and wandering, with momentary survivors adapting to changing local environments, not approaching cosmic or engineering perfection."

Still another prevailing fallacy is that living things can evolve by deliberately adapting to their surroundings; that, for example, giraffes evolved into long-necked creatures because, for thousands of generations, they stretched their necks so they could reach the leaves of trees. But that's not what the theory of evolution propounds. Instead, it says that changes evolve when the genes of an organism are altered, resulting in a new characteristic, like a longer neck. If the new characteristic proves advantageous to survival, the organism may well live longer than usual and be able to produce more offspring. The offspring are capable of inheriting the altered genes, resulting—in the case of the giraffe—in additional long-necked creatures. These long-necked offspring will, like their parents, have a survival advantage, permitting them to live longer and produce still more offspring, many of them with long necks. The chain continues until the long-necked variety takes over the territory.

According to the classical theory of evolution, it is only genetic changes—mutations—that can be passed on. Any change caused by stretching, or by any other kind of effort, cannot be inherited; it has no evolutionary effect.

There exists an excellent example of the fact that characteristics not acquired genetically cannot contribute to an organism's evolution. For thousands of years, male Jewish infants (as well as the boys and girls of several African tribal groups) have, almost without exception, been circumcised. Yet not once has there been a report of a child being *born* circumcised. It's simply not in the genes.

Facts About 2 Animals and Plants

Common knowledge about human beings may sometimes be faulty, but no more so than about animals and plants. Our perception of *all* living things is frequently obscured by the mists of misinformation, as in the following examples.

OSTRICHES DON'T STICK THEIR HEADS IN SAND

Pliny, a Roman author who lived about two thousand years ago, wrote that ostriches hid from predators by sticking their heads in sand and that they believed if they no longer saw the enemy, the enemy could no longer see them!

No reputable observer has ever caught an ostrich "in the act," but this lack of confirmation has seldom discouraged writers, speakers, or cartoonists. They continue to present this notion as fact because it provides such an apt metaphor for someone who tries to avoid the truth by ignoring it. They don't realize, apparently, that by using such a metaphor, they commit the same blunder.

[FIGURE 5]

ELEPHANTS DON'T DO *ANY* OF THOSE THINGS

What things don't elephants do? Things like traveling to elephant graveyards to die . . . running away from mice . . . displaying amazing feats of memory. None of these marvelous-if-only-they-were-true traits have ever been proved to exist. Too bad!

Equally erroneous, but the result of poor observation rather than fanciful invention, is the belief that elephants drink through their trunks. They *do* lift water with their trunks but then, when thirsty, squirt it into their mouths.

OWLS CAN'T SEE IN THE DARK

Owls are excellent hunters, supposedly capable of seeing their prey in absolute darkness. In truth, they can't. They do have exceptionally large eyes, enabling them to see quite well in dim light. They also have very sensitive ears. Their acute hearing, more than their superior vision, accounts for their ability to hunt in the dark.

THE SWALLOWS OF CAPISTRANO DON'T FLY TIGHT SCHEDULES

The swallows of Capistrano, California, are supposed to return from their southward migration on March 19 of every year. Even leap year doesn't throw them off schedule. That, at least, is what 1,001 annual newspaper stories say. That also is what a once-popular song assured us. And that's what the publicity people of Capistrano practically guarantee us. It's all very convincing and crowd-pulling.

Unfortunately, swallows cannot read and don't get the message, so they're not aware they're expected to follow a tight schedule. The time of their return really depends on their food supply; large numbers of insects must appear along their route before they are able to travel. The presence of insects depends, in turn, upon the return of warm weather.

Swallows come back to Capistrano, not just on March 19, but over a period of weeks. Many of the "swallows" that are there on the nineteenth are actually swifts, an unrelated but swallowish-looking bird that never left the neighborhood.

The fact that swallows come back to Capistrano each year, after migrating thousands of miles, is one of the wondrous glories of nature, no matter how loose the timing may be.

GROUNDHOGS CANNOT PREDICT THE WEATHER

The groundhog is an even better friend of newspaper reporters than is the Capistrano swallow. Scarcely a single daily paper in the United States fails to write a piece on "Groundhog Day," come February 2. The reporters' "eyewitness" accounts tell how a groundhog leaves the hole where it has been hibernating during the winter to look around. If it sees its shadow, the animal knows there will be six more weeks of cold weather and returns to its hole.

There's no solid evidence that the groundhog can foretell the weather any better than can, say, his cousin, the rat. The weather will be what it will be, shadow or no shadow. A groundhog isn't a fortune teller; he ain't nothin' but a rodent.

A CAMEL'S HUMP DOES NOT CONTAIN WATER

A camel's hump consists mostly of fat, not water. However, when fat is used for energy (by camels or any other animal), hydrogen is released internally as a by-product. This is combined with the oxygen that the camel inhales,

[FIGURE 6]

producing water (H_2O). Also, camels are able to retain water better than most animals because they sweat very little.

So camels are able to go for days in the hot sun without having to drink, not because they store water in their humps but because, to a greater degree than most animals, they create their own water and are adept at conserving it.

If you ever ride a camel, can you expect to hear water sloshing around in the animal's "tank"? Fat chance!

BATS ARE NOT BLIND

To be "blind as a bat" is supposed to mean you are very blind, indeed. Yet the facts reveal that bats are not blind at all. They're not even nearsighted. When there is light, they see perfectly well. And when there is no light, bats can avoid obstacles by employing a kind of sonar system. It works this way: bats emit squeaks that strike nearby objects. The sounds bounce back to the bats' ears, identifying the objects as something to dodge or to eat.

Contrary to widespread fears, bats do not blunder onto people's heads and become entangled in the victims' hair. In experiments conducted in pitch-black rooms, bats' sonar permitted them to avoid pieces of hairlike string dangled in their way. If they can do *that*, bats certainly must be able to avoid hairy heads.

PIGS ARE NOT PIGGISH

Pigs are by nature neither dirty nor gluttonous, but they may seem that way because of conditions imposed on them. Pigs are frequently confined to small, sloppy sties and are often fed garbage, though it's scarcely their preference. Pigs wallow in mud, but that's because they have no sweat glands and cannot perspire. Coating themselves with damp soil is their way of cooling off.

Pigs happen to be unusually intelligent animals that are easy to train. Also, their internal organs are so similar to those of humans that they are widely used in experiments to help us learn more about our own bodies.

SOME ANIMALS ARE LESS DANGEROUS THAN WE SUPPOSE

Horror fascinates us, as can be seen in movies, on TV, and in books. That may be why we're so quick to accept the most dreadfully exaggerated accounts of animal behavior. A rampaging gorilla. A voracious piranha. A poisonous viper.

The viciousness of animals may be an idea that is easy to sell, but it is not so easy to prove. Studies of gorillas in their natural surroundings assure us that a typical gorilla eats mostly vegetables, is actually mild-mannered, and seldom uses its great strength in anger. It's more of a pussycat type than a King Kong.

A piranha is a small, relatively insignificant fish found along parts of the Amazon River in Brazil. Yet the fish is infamous all over the world. Why? Because, reputedly, a small school of them can reduce to a skeleton any human unlucky enough to step among them. And it takes only a few minutes. What a deliciously horrible idea! But is it true? An authority on dangerous fish, Edward Ricciuti of the New York Zoological Society, reports that there has never been a proven case of a piranha doing anything worse to a human than giving him or her a bad bite. The piranha is not exactly the ideal fish-tank pet, but it's not the miniature monster it's made out to be.

The "character assassination" of animals is widespread. Sometimes, as with certain sharks, an animal's personality almost lives up to its reputation. More often, the accusations are unfair, especially because animals do what comes naturally; they have no sense of right or wrong. Even the sinister-looking tarantula, the giant spider so beloved by directors of horror films, is far from being a killer of people; thousands of them have made fine pets! They *could* prove fatal, especially to someone hypersensitive to their venom; but the same is true of bees or even the tiny fire ant.

Since early times, the most hated villain in the animal kingdom has been the snake. Unjust! True, in parts of the world, particularly Southeast Asia, snakes kill thousands of people every year. But these regions contain the greatest number and the most venomous types of snakes. Most significantly, these are places where fast-growing populations are crowding into the snakes' natural habitats and where many people go barefoot.

There are nearly twenty-five hundred kinds of snakes in the world. Only about two hundred are poisonous to humans, and only a fraction of these are deadly. In the United States, despite its rattlesnakes, copperheads, water moccasins, and other dangerous species, fewer than forty persons are killed by snakes in an average year. Many more than that number are bitten; but even a rattler's bite, while extremely painful, is not usually fatal, especially when the victim gets prompt treatment.

Humans are often called the most bloodthirsty of all the animals, and maybe they are. But the pronouncement that "they're the only ones who kill their own kind" is just not true. Jane Goodall, an authority on chimpanzees, has seen gangs of chimps kill individual members of other chimp groups when they catch them alone.

Rats, of course, are well-known rat killers. And hamsters, those cuddly pets, frequently kill each other and sometimes eat their own offspring. Talk about child abuse!

Many fish eat their own kind, especially if the morsels are young and bite-size. Among the most notorious cannibals are insects and spiders; the female praying mantis (an insect) and certain female spiders actually consume their mates, right after mating.

Then there's the graceful sea gull, which will consume almost anything, even another sea gull, if it happens to be injured. The same applies to that symbol of peace, the dove.

Now consider domestic fowl. A chicken with a bloody cut can expect to be pounced upon by its brethren and finished off. Turkeys? They're so destructive of one another that farmers clip their beaks or take other measures to make them less deadly.

And what about the widely held contention that humans are the only creatures who kill for the fun of it? Did you ever see a cat play with a mouse before killing it?

MILK IS NOT A NEARLY PERFECT FOOD

Milk is one of the most delicious of foods. It is also one of the most useful; milk is the main ingredient of butter, cheese, ice cream, yogurt, and other products. For the money, milk contains unusually large amounts of proteins, vitamins, and minerals (it's one of the most important sources of calcium, a mineral necessary for the building of strong bones).

But can we justify the widely held claim that milk is the world's most nearly perfect food?

Human milk certainly seems to be the best source of nutrition for infants less than six months old. Beyond that age, however, a large part of the world's population—some authorities say as much as half—have difficulty digesting any kind of natural milk. This condition is particularly true for large groups of blacks, Asians, and Jews. Lactose, an ingredient in milk, can be troublesome, sometimes causing nausea, gas, and diarrhea.

Milk companies have been developing ways of making milk acceptable to those who can't tolerate lactose. But for the time being, milk cannot be graded or described as "perfect."

COWS GIVE MILK ONLY AFTER CALVING

As with a human mother, a cow can produce milk only after giving birth. After a while, its milk supply dries up, unless and until it calves again.

Although a cow gives milk only part-time, it produces more milk than its calf requires. The surplus is used by the milk industry and its customers. An average American cow weighs somewhat more than 1,000 pounds (450 kg) and, in a year, can produce approximately its weight in milk. Some prize cows can produce more than three times their weight!

More about cows—and bulls: some of us have been heard to say that if it has horns, it's a bull. Not so. Cows, as well as bulls, have horns; but if it has an udder, it's a cow.

Contrary to popular belief, bulls, including the fighting variety, are not aroused by red or any other color. Like many kinds of mammals, they are color-blind. It's the *movement* of an object that may cause a bull to feel challenged and to charge, whether the object is a waving red cape or a pair of retreating blue jeans.

WHITE EGGS ARE NOT BETTER THAN BROWN EGGS

In most parts of the United States, white eggs are preferred to brown, though in a few regions—notably the Boston area—the reverse is true. Is there a rational reason for the preference? If so, the experts can't find it. The U.S. Department of Agriculture says this: "Shell color is determined by breed of the hen and does not affect the grade, nutritive value, flavor, or cooking performance of the eggs."

GRADE AA EGGS ARE NEITHER LARGER NOR MORE NUTRITIOUS THAN GRADE A OR GRADE B EGGS

When we buy Grade AA eggs, we pay a premium. Why? Not because of size (that's a separate type of gradation). And not because of nutritive value.

Pamphlets from the Department of Agriculture say that "grade refers to interior quality, and to the condition and appearance of the shell." An AA egg, when emptied into a pan, "covers a small area; the white is thick, stands high; the yolk is firm and high."

It would seem that only appearance counts. However, although the pamphlet neglects mentioning it, there is a relationship between appearance and *freshness:* as an egg loses freshness, it becomes less firm and, when emptied into a pan, lies flatter and more spread-out than does a fresh egg.

A TOMATO IS A FRUIT

What's in a word?

It all depends.

Take the words *vegetable* and *fruit.* A biologist will tell you that *vegetable* is another word for *plant*; it covers the entire plant kingdom, from giant trees to microscopic bacteria. In ordinary use, though, *vegetable* has a more limited meaning: it is the edible part of a plant—but only *certain* plants. Celery is the stalk of the celery plant, and is considered a vegetable. So is a sweet potato (a root), a white potato (an underground stem), and lettuce (a leaf).

The tomato, the edible part of the tomato plant, is also commonly called a vegetable. However, a grape is *not;* it is called a fruit, at least in common usage. But just what is a fruit? Scientifically, it is "the part of a plant that contains the plant's seeds." Strictly speaking, therefore, a tomato is a fruit since, like the grape, it contains the plant's seeds.

Similarly, the peanut and its shell, taken together, are a fruit. So are the cucumber, the squash, and dozens of other "vegetables."

Fruits? Vegetables? No matter. By any name, they would taste as sweet.

THE SEEDS OF A McINTOSH APPLE WILL NOT GROW INTO A McINTOSH TREE

It's sensible to assume that if we plant the seed of a McIntosh apple, it will grow into a tree that bears more McIntoshes.

Sensible, yes. Accurate, no.

Here are the facts: there isn't any variety of apple whose seeds will produce trees that bear the same type of apple. (This applies to many fruits, vegetables, and flowers.)

For thousands of years, insects have carried the pollen of one variety of apple tree to the blossoms of other varieties. The result of this continual cross-fertilization is seeds that contain an incalculable mixture of genes from hundreds of "ancestors." Therefore, the kind of tree that will grow from any particular seed is unpredictable, except that it will probably be unlike any tree ever grown from any other seed—even another seed from the same apple. In other words, each tree grown from a seed will be unique; it will bear fruit of a brand new variety.

Usually, the new varieties have poor taste or are otherwise undesirable. Once in a while, however, a new variety is worth continuing. But how is this done? Its seeds, being hybrids, will not breed true.

Fortunately, there is a solution. If a shoot with buds is cut from the desirable tree and attached, by grafting, to an apple tree whose top has been cut off, a new tree will grow, and this one will bear apples like those of the desirable tree.

In 1811 a Canadian farmer, John McIntosh, chanced upon a hybrid tree that bore especially delicious apples. By the use of grafts, the McIntosh variety spread to many parts of America.

Every one of the millions of McIntosh trees now in existence can be traced to grafts from the original tree, or from grafts of grafted McIntosh trees!

Since all appleseeds are hybrids, Johnny Appleseed, when he blazed his famous trail, had no way of knowing what the results would be. He'd have been safe predicting that most of the apples-to-come would be almost worthless, for that's the usual fate of appleseeds. For all he knew, they might all have proved to be lemons.

THERE ARE MALE TREES AND FEMALE TREES

Trees, along with all other seed plants, reproduce sexually. They have male parts that produce sperm cells (pollen) and female parts that produce egg cells (ova). With some kinds of plants, a single member has both male and female characteristics; with other kinds, a single member changes sex during its development; with still other kinds, a single member is either male or female.

Most of us know about the sexual nature of flowers, but we seldom realize its existence in trees. We are especially unaware that there are species whose individuals are either male or female. Among the most common single-sex trees is the ailanthus, a species that thrives in city streets, even where pollution is heaviest. If you ever see an ailanthus loaded with seeds, you know you're looking at a female. And you can be equally sure that, not far away, there is a male that supplied the pollen to fertilize the ova that developed into the seeds you are seeing.

PLANTS *TAKE IN* OXYGEN, AS WELL AS GIVE IT OFF

If you've had even an elementary science course, you know about the most profitable "exchange" in nature: animals take in oxygen and give off carbon dioxide, while plants complement the process by taking in carbon dioxide and giving off oxygen. A perfect deal!

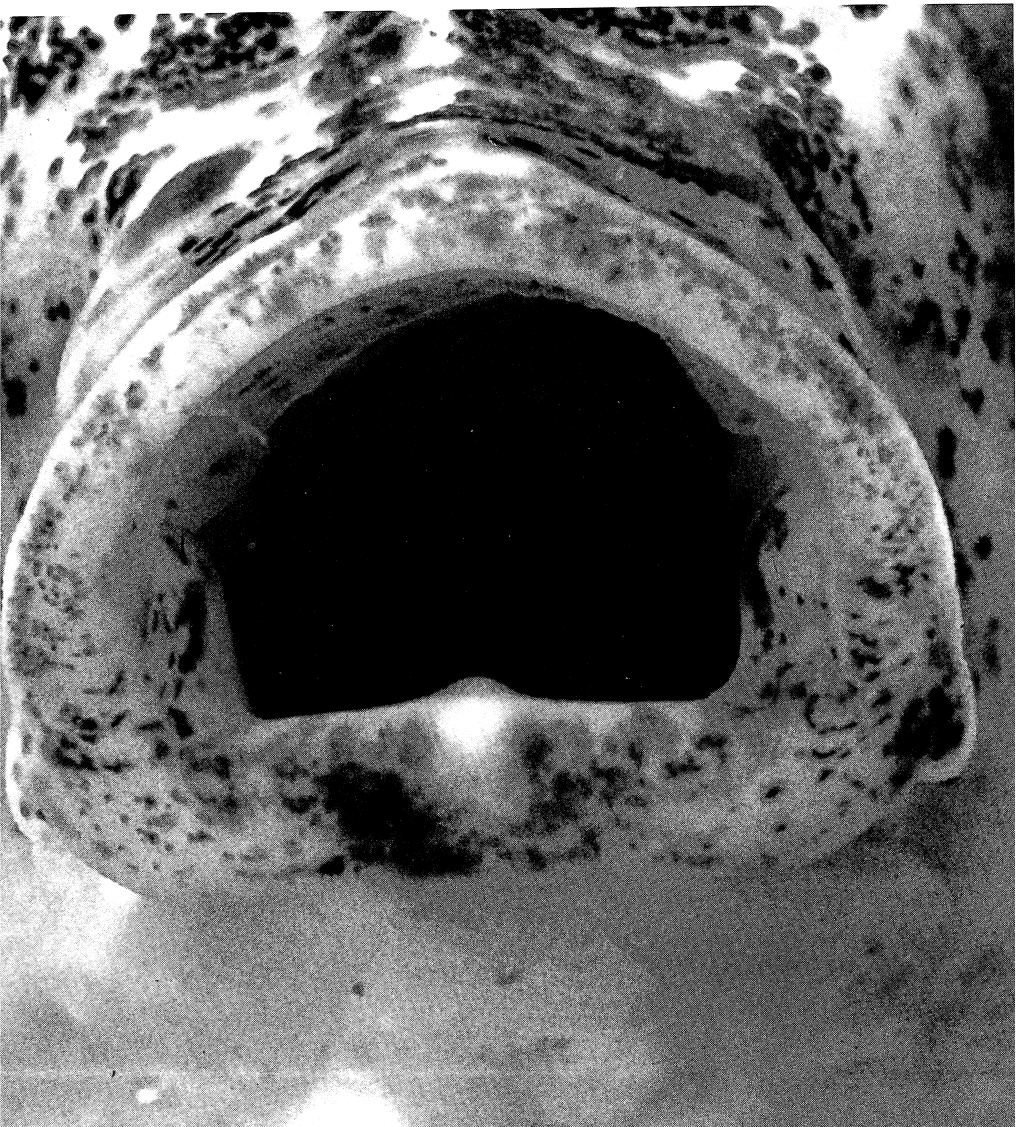
Plants use carbon dioxide as an ingredient in making their food. A waste product that results is oxygen. The oxygen "waste," expired into the air, is virtually the sole source of the oxygen in our atmosphere.

Animals need this oxygen. Their food must be burned (flamelessly) if the food's energy is to be released and utilized, and burning cannot take place except in the presence of oxygen. The burning, or "oxidation," process creates a waste product, carbon dioxide, which is exhaled into the air and ultimately used by plants.

But plants too must oxidize their food to extract its energy. In other words, plants, as well as animals, must use oxygen. And they do; they take it in, just as animals do. However, they *do* give off far more than they take in, for the production of food is a larger scale operation than is oxidation.

FISH DO NOT GET THEIR OXYGEN FROM THE OXYGEN COMPONENT OF WATER

Fish, like all animals, must take in oxygen. They get it by passing water across lunglike gills, which absorb the oxygen that is in the water. But, contrary to customary assumptions, this oxygen does not come from the oxygen that, with hydrogen, composes water (H_2O). It comes instead from oxygen that is mixed with, but separate from, H_2O.



Fish take in oxygen given off by plants and from air mixed in the water by waves.

[FIGURE 7]

This supply of "free oxygen" consists partly of the oxygen given off as waste by underwater plants when (like land plants) they make their food; the rest comes from oxygen that was in the atmosphere but has been mixed into the water by waves, wind, and other stirring action.

What's true of ordinary fish is also true of pet fish: they need oxygen but they can't get it from H_2O. That's why fish tanks should contain plants, as well as aerators that pump air into the water.

Facts About the Earth

3

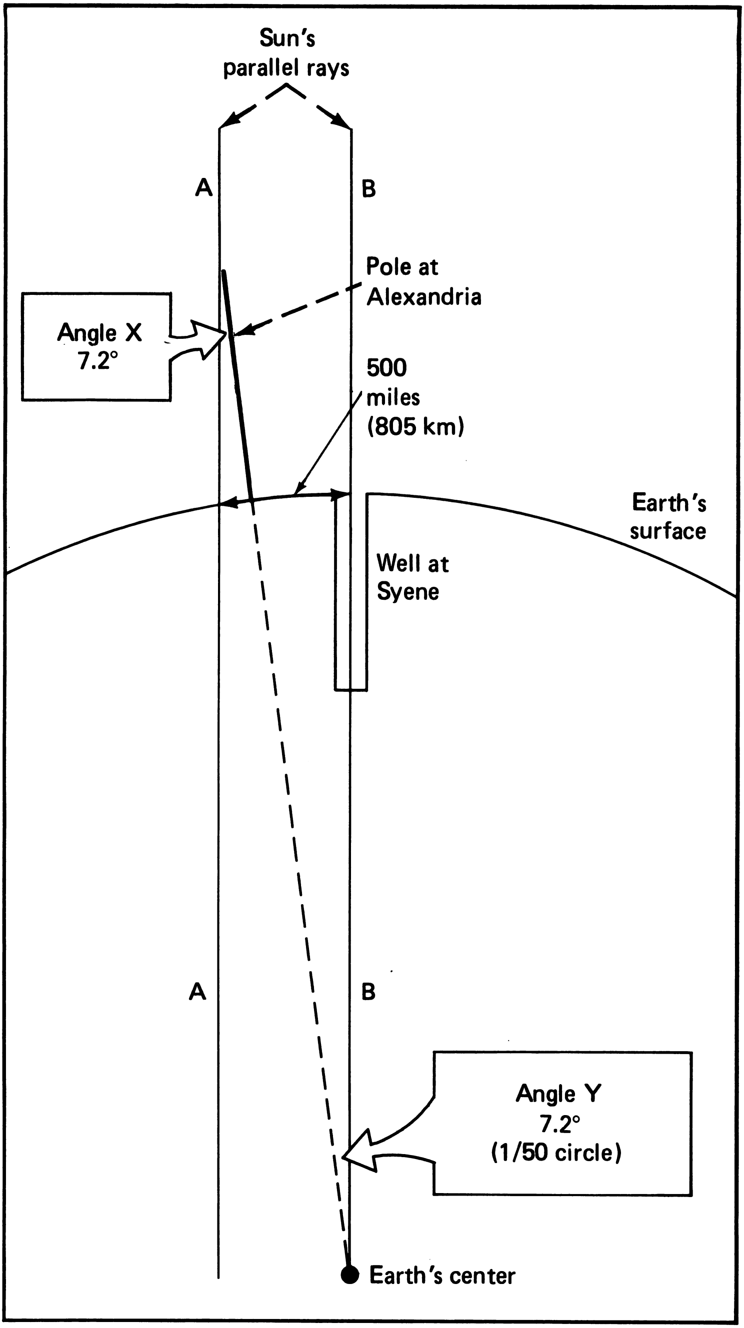
The earth is our home in the universe. Understandably, we know a lot about our home. That's as it should be. But a good deal of what we know just isn't true.

THE EARTH ISN'T ROUND

We all say that the earth is round. Yet, it's not exactly round, for round more accurately describes a circle or a flat, circular disk, such as a nickel or a dime. More precisely, the earth is a sphere. Yet it is not exactly a sphere, either. It's really a slightly lopsided sphere that astronomers call an *oblate spheroid.* (Its diameter from pole to pole is about 30 miles [48 km] less than its diameter across the equator.) Round, sphere-shaped, oblate—any of these terms can be used to describe the earth, since we all know we're talking about an object that looks like a ball.

COLUMBUS WAS NOT THE FIRST TO REALIZE THE EARTH WAS ROUND

We may know what we're really talking about when we say the earth is "round" but we *don't* know what we're talking



Sun's parallel rays
A
B
Pole at Alexandria
Angle X 7.2°
500 miles (805 km)
Earth's surface
Well at Syene
A
B
Angle Y 7.2° (1/50 circle)
Earth's center

[FIGURE 8]

about if we say that it was Christopher Columbus who first realized it was round.

More than two thousand years ago, Eratosthenes, a Greek mathematician living in Alexandria, Egypt, not only felt certain the earth was round but also accurately estimated its size!

Here's how science historians think he did it. (With the help of Figure 8, you should be able to follow his reasoning, even if you aren't a whiz at math.)

First of all, Eratosthenes knew that the sun's light comes to us in parallel rays—a fact that had previously been established. He also knew that in Syene, Egypt, (now Aswan) at the middle of the longest day of the year, the rays went straight down the city's wells; that is, the rays on that day were perpendicular to the earth's surface. At the same moment in Alexandria, which was 500 miles (800 km) to the north, the parallel rays struck the earth at an angle of 7.2 degrees. This angle could be measured by the shadow cast from a pole placed perpendicular to the ground.

The fact that the sun's parallel rays struck one part of the earth's surface perpendicularly and, at the same instant, struck another part at a 7.2-degree angle, was in itself evidence that the earth was certainly not flat, and might well be round. (This was but one of many clues that convinced scholars, even before the time of Eratosthenes, that the earth was round.) Eratosthenes wanted to know just how *big* this sphere, the earth, was. He wanted to calculate its circumference.

Assuming that the earth was round, he drew a diagram that probably resembled the one shown here. You can see that if lines A and B are parallel and if angle X is 7.2 degrees, then angle Y, at the center of the earth, must also be 7.2 degrees.

A full circle happens to contain 360 degrees; 360 is equal to 50 times 7.2 ($360 = 50 \times 7.2$). In other words, angle

Y makes up one fiftieth of the circle formed by the round earth. It follows that the distance between Alexandria and Syene—500 miles (800 km)—must be one fiftieth of the earth's circumference. The circumference is, therefore, 50 times 500 miles (800 km), or 25,000 miles (40,000 km). That estimate is only a few hundred miles from the actual figure!

GRAVITY *DIMINISHES* AS WE GO DEEPER BENEATH THE EARTH'S SURFACE

The strength of gravity weakens with distance. In calculating these distances, we measure from the center of the source of that gravity; in the case of the earth's gravity, we measure from the center of the earth.

If we could stand on an imaginary tower that reached far into space, we would be pulled with less gravitational force—and would therefore weigh less—than if we climbed part way down, closer to the earth's center. And if we then got down to the earth's surface, we'd be still closer to the center of the earth and would weigh even more.

Knowing this, we might assume that if we could go far *beneath* the earth's surface, closer to its center, we'd become very heavy indeed.

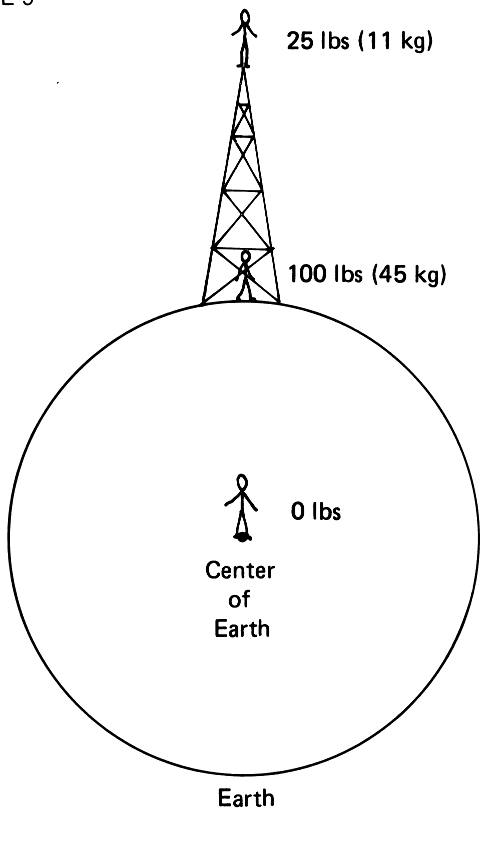
But the truth is, we'd become lighter!

Gravity is related to the *mass* of an object, that is, to the amount of "stuff" the object contains. The greater the mass, the greater the force of gravity.

The earth is massive, and its gravity is correspondingly strong; it controls the path of the moon and reaches far beyond that.

The closer an object gets to the earth, the stronger the earth's pull of gravity. The maximum pull occurs on the earth's surface, for then the entire mass of the earth is

FIGURE 9



underfoot. However, if we were to go down a deep mine, some of the earth's mass would then lie *above* us, tugging us upward and partly counteracting the downward pull created by the rest of the earth's mass. If somehow we could get to the very center of the earth, we would be pulled equally in all directions. We would be weightless! (Figure 9).

A COMPASS DOES NOT POINT TOWARD THE NORTH POLE

A compass—the kind that shows directions—does not point true north (toward the North Pole). It points instead to the North *Magnetic* Pole, a place that is several hundred miles from the North Pole and that shifts slightly from year to year.

A compass works because it has a free-swiveling needle that is really a tiny magnet; and the North Magnetic Pole acts like the end of a gigantic, earth-size magnet that attracts all other magnets, including compass needles.

PRACTICALLY NO SNOW FALLS AT OR NEAR THE SOUTH POLE

Temperatures as low as minus 127° F (minus 88° C) have been recorded at the South Pole. It is the coldest part of the earth.

The South Pole is near the center of a frigid continent, Antarctica, much of which lies beneath more than a mile (1.6 km) of snow-topped ice. Yet practically no snow falls at or near the Pole!

Most of Antarctica is a desert with even less precipitation than almost any other desert in the world. The South Pole station of the United States government receives, on the average, only a fraction of an inch of snowfall in a year. Compare that to 30 inches (76 cm) in New York City, 43 inches (109 cm) in Chicago, 60 inches (152 cm) in Denver, 113 inches (287 cm) in Caribou, Maine, and 246 inches (625 cm) at Mt. Washington, New Hampshire! Snowfall in Alaska is still greater, and there are even places in Texas and other southern states with more snowfall than the South Pole.

Because of the year-round cold in the region and because its snow-white surface reflects the sun's heat back into space, very little of the snow that does fall ever warms up enough to melt. After more than a million years, the accumulation has pressed together and largely solidified, forming the continent's thick covering of ice. Another surprising fact is that there is far more fresh water locked in this immense cake of ice than there is in all the rivers and lakes of the world.

THE EARTH HAS FIVE? FOUR? THREE? TWO? ONE? OCEAN(S)

Some of us have learned that there are five oceans: the Pacific, the Atlantic, the Indian, the Arctic, and the Antarctic. Others have learned there are only four; many geographers dismiss the Antarctic as being merely those parts of other oceans that happen to surround the continent of Antarctica. A few experts also exclude the Arctic because it is so small. Some say the Indian shouldn't be counted either, for it is just a bridge between the Pacific and the Atlantic. And many authorities maintain there is really only *one* ocean; it has no formal name—just call it the Ocean or the Sea.

Those who advocate one ocean are convincing. They point out that if we examine a globe, we quickly see that ours is a water planet, with water covering nearly three-fourths of its surface. It is one big ocean, with some land here and there. Its oneness becomes even more apparent when, using a finger as a "ship," we find that we can sail from any part of the Ocean to any other part. (Figure 10.)

Different sections of the ocean were originally given separate names because people believed each part was an individual body of water contained in a basin surrounded almost completely by large, dominating land areas. Today we know that even continents are mere islands in a great sea.

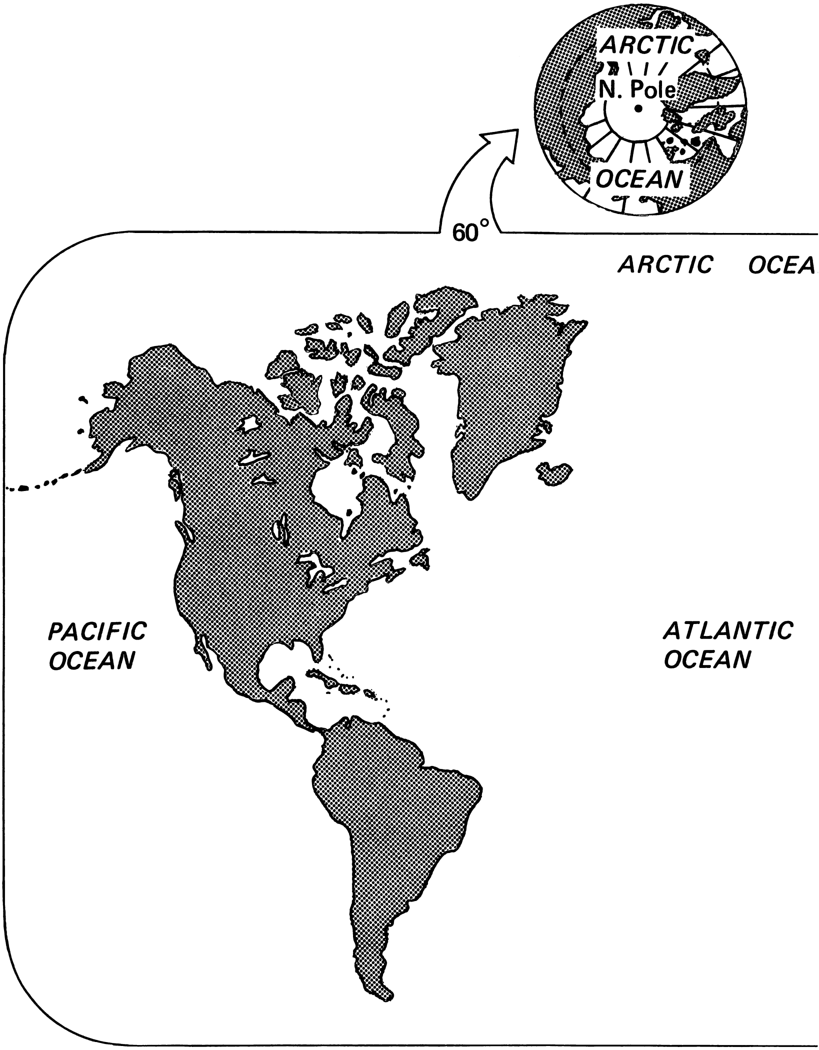
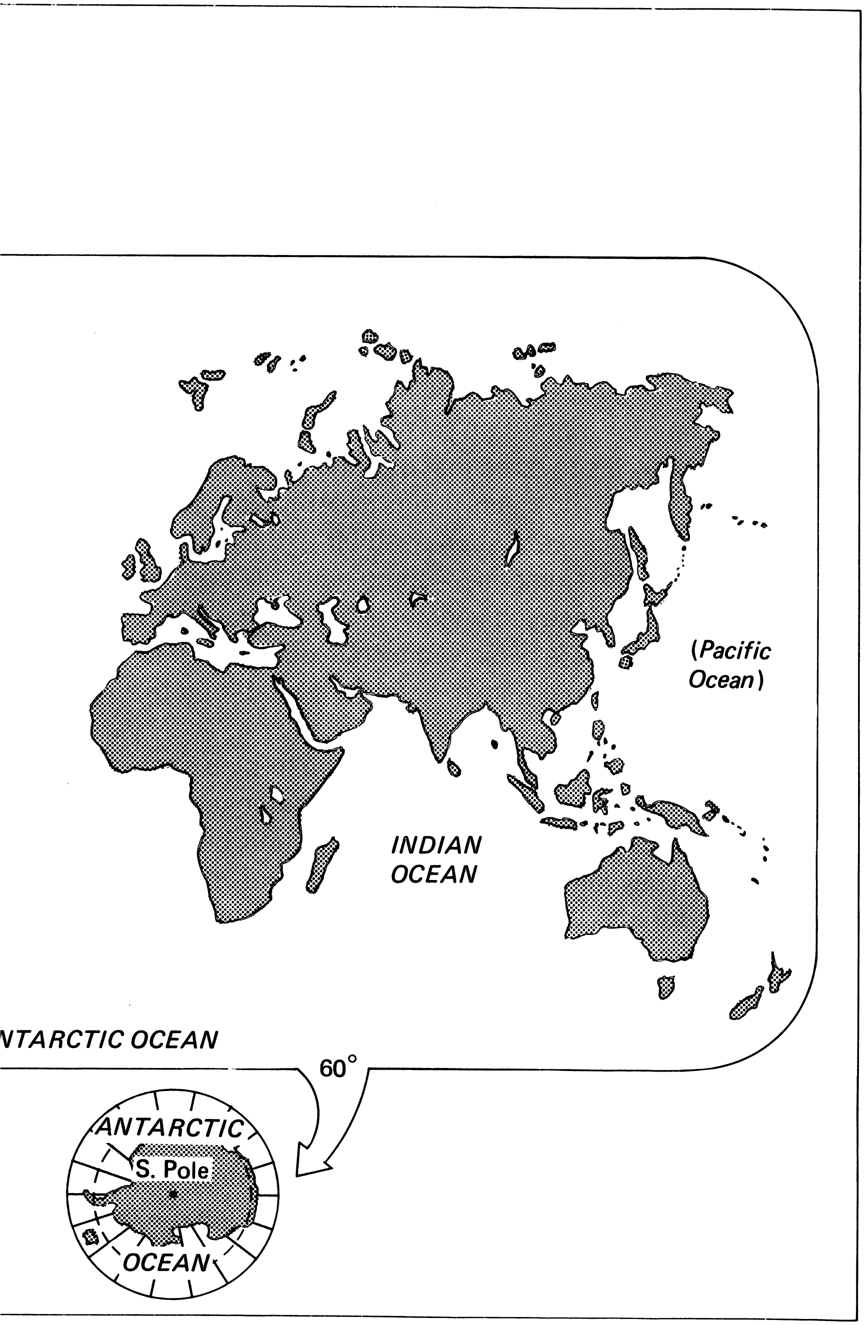

ARCTIC
N. Pole
OCEAN
60°
ARCTIC OCEA
PACIFIC
OCEAN
ATLANTIC
OCEAN

FIGURE 10


(Pacific
Ocean)
INDIAN
OCEAN
NTARCTIC OCEAN
60°
ANTARCTIC
S. Pole
OCEAN

MOST TROPICAL JUNGLES HAVE POOR SOIL

It seems logical to assume that tropical rain forests—those jungles where plants grow so rapidly and profusely—have rich soil. That is what the governments where the forests are located also once assumed. The pressures of expanding populations caused many of these governments to level the jungles at a rapid rate, partly to harvest wood and other forest products, but mostly to gain farmland. Unfortunately, most tropical rain forests, once cleared of their lush vegetation, proved so infertile that they were unable to sustain crops for more than two or three years. Hopeful farmers usually discovered that only the top inch (2.5 cm) or so of soil had the nutrients plants need in order to thrive, and these nutrients were soon used up.

Soil nutrients—minerals—come naturally from rotted leaves and other decayed vegetable matter that litters the ground. This *humus* is dissolved by rain and sinks into the ground where, normally, its minerals are absorbed by the roots of living plants.

Unfortunately, much of the soil in the tropics consists of a heavy, almost rocklike clay. The decomposed ground litter cannot sink into this impermeable ground, but instead is washed away into rivers by the heavy rains characteristic of rain forests. Where there *is* porous soil, the torrential downpours tend to leach the minerals deep into the ground, beyond the reach of roots. As a result, these jungle lands seldom have the thick, dark, humus-rich layer of topsoil necessary for sustained farming.

For a long time, scientists wondered how an area unsatisfactory for growing crops could nonetheless support the most lush vegetation found anywhere on the earth. They eventually discovered that tropical jungles have a growth cycle that practically bypasses the soil beneath it!

In their hot, humid environments, dead vegetation decays quickly, but living vegetation carries on its life functions just as quickly. Roots are able to extract adequate quantities of minerals from the rotting mat that covers the ground and do so before these minerals can reach the soil, where they would be flushed or leached away.

OUR ATMOSPHERE IS NOT HEATED DIRECTLY BY THE SUN

The sun's rays are not, in themselves, hot; and if they pass through a transparent substance such as clear air, they do not affect its temperature.

Nor do the rays affect a transparent substance such as a clear, clean sheet of glass. If, in midafternoon on a hot sunny day, you were to place a piece of such glass in an upright position for five minutes or so, it would feel cool to the touch. The "hot" sun's rays would not have warmed it but would have passed right on through.

However, when the sun's rays strike a substance that is *not* transparent, rays are absorbed and heat is created. The absorbed radiation causes the substance's molecules (the invisibly small particles of which all matter is composed) to vibrate rapidly. This vibration is the essence of heat; the faster the vibrations, the greater the heat, and vice versa.

If you were to paint one side of the glass, especially with a dark color, the paint would absorb rays and become hot. The paint's vibrating molecules would then bump against the molecules of glass, with which they are in contact, and cause *them* to vibrate, too. In that way, heat would be conducted to the glass, as would become apparent if you touched even the unpainted side of the glass—it would feel hot.

In other words, radiation can't heat a transparent substance directly but can do it indirectly, by first heating an adjacent substance that is *not* transparent, which then conducts its heat to the transparent material.

As with the glass, the sun's rays pass through the atmosphere and heat the surface of the earth, which in turn heats the layer of air at the bottom of the atmosphere—the layer with which the surface is in contact.

But how does the rest of the atmosphere become heated?

As a substance becomes warmer, its molecules vibrate more vigorously, bouncing farther apart from each other. Because they're farther apart, a "piece" of warm air contains fewer molecules than a "piece" of cool air. Since warm air contains fewer molecules for its size, it weighs less than cool air. Air that has been warmed by the surface of the earth is therefore lighter than the cool air above it. Because of gravity, the cool, heavy air sinks to the earth's surface, pushing aside the warm, light air. The only place for the displaced, light air to go is up, into the space left by the heavy air.

The descended air then gets heated by the earth's surface and becomes lighter. It, in turn, is forced up by a fresh supply of cool, heavy descending air, and so on. By this process, called *convection,* warm air is circulated throughout the atmosphere.

THE SUN DOES NOT CAUSE SEASONAL CHANGES

During some months of the year, the sun is as much as 3,000,000 miles (4,800,000 km) closer to the earth than it is during other months. We're sometimes told that this explains our seasons. Since the sun is about 93,000,000 miles (148,000,000 km) away, a mere 3,000,000 miles (4,800,00 km) is too small to account for seasonal changes.

Even if the difference did matter, how would we explain why the Northern and Southern hemispheres have opposite seasons (when it's winter in one hemisphere, it's summer in the other) even though both hemispheres are equally distant from the sun at any one time? And how would we explain why, in the United States, when the sun is closer it is winter, and when the sun is farther away it is summer? Surely, the differences in distance between the sun and the earth have little significance in determining our seasons.

Sunspots—explosions of activity on the sun's surface—affect the energy released by the sun, but the spots occur irregularly and have no correlation with the recurring pattern of the seasons.

The simple fact is that the earth receives, every minute of the year, a virtually constant stream of solar rays. What, then, is responsible for the seasons?

It's commonly known that, in midsummer, the sun gets farther overhead—more nearly *perpendicular*—than at other times of the year. Perpendicular sunlight *does* produce more heat than does sunlight that strikes at a sharp angle. Most of us probably assume that the differences in angles are due to the movement of the sun; part of the year it's more or less directly above the Northern Hemisphere, with the Southern Hemisphere receiving only oblique rays, while during another part of the year, the sun's position has changed and the reverse is true.

Such movements of the sun are an illusion, just as are the "movements" of the sun across the sky in the course of a day. In both cases, the sun, for all practical purposes, is stationary. It is the earth that is responsible for the changes.

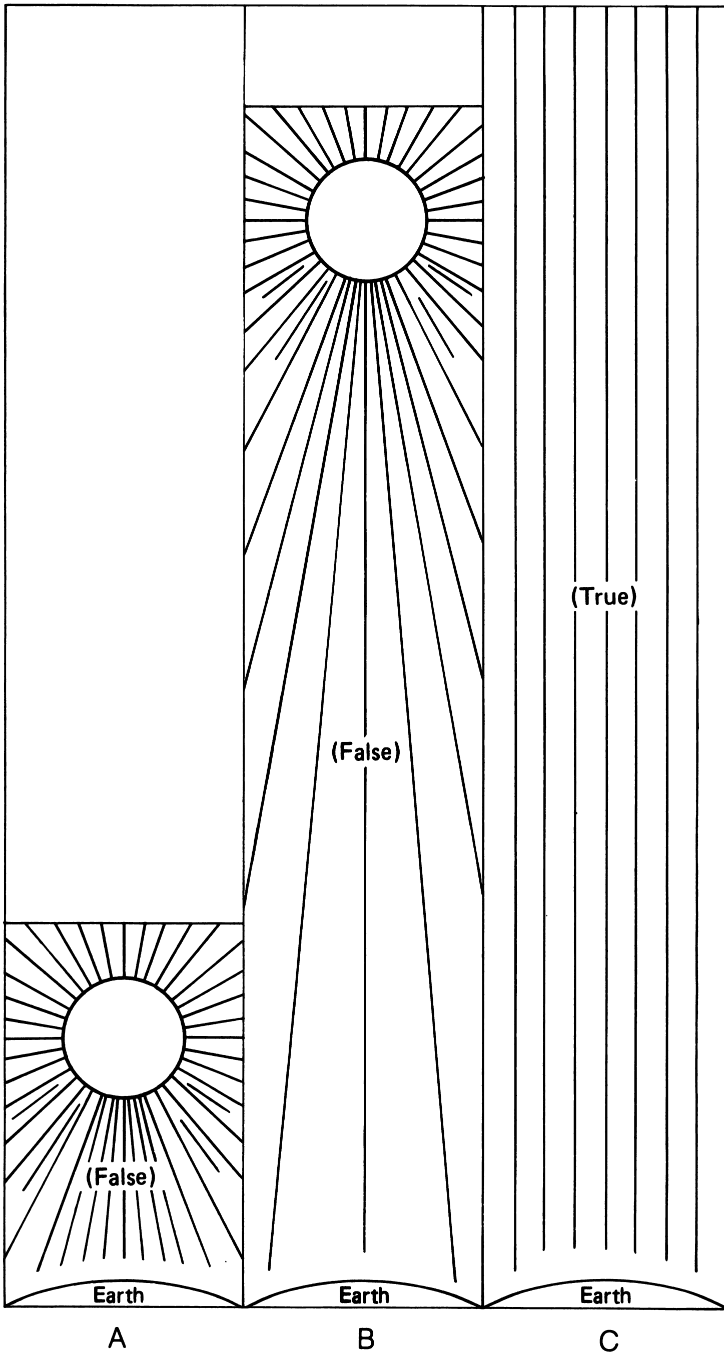
To understand what really happens, we must first understand a fact that has been known for at least two thousand five hundred years, but never widely recognized: the earth not only receives a steady stream of energy from the sun but also *receives it in virtually parallel rays.*

By examining the accompanying illustrations, you may gain a better understanding of how sunshine reaches us in parallel lines. If, as in Figure 11a, the sun were only a few thousand miles away, the rays would reach us in diverging lines, like the spokes of a wheel, and for that reason would simultaneously strike the earth at different angles in different places. If, however, as in Figure 11b, the sun were a few hundred thousand miles away, the rays that reached the earth would be more nearly parallel than in the previous example. But if the sun were *millions* of miles away (the actual figure is approximately 93,000,000 miles or 149,000,000 km), then for all practical purposes the only rays reaching us would arrive in parallel lines. (Figure 11c.)

Sometimes the sun's rays seem anything but parallel. On cloudy days when there are many small particles in the sky, sunlight sometimes emerges in what seems to be diverging lines through small openings in the clouds. (Figure 12.) But seeing is not believing. It's an illusion often compared to the illusion we experience when looking outward along railroad tracks or along a wall made of rows of bricks. We know that the rails and the brick rows are parallel, but they seem to converge at a point in the distance. (Figure 13.)

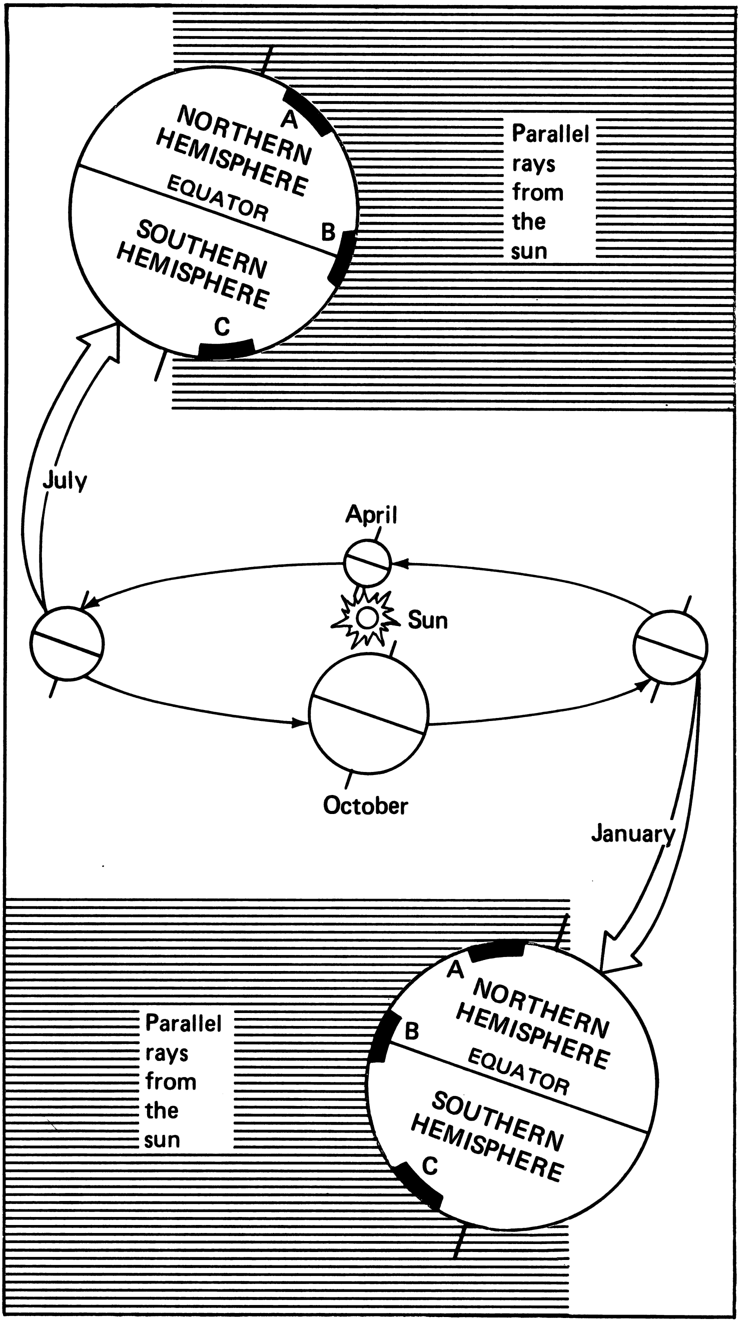
Despite the fact that the sun's rays arrive in parallel lines, they manage to strike one part of the earth perpendicularly; another part, at a sharp angle. The explanation lies with the earth: it is curved!

The top part of Figure 14 shows the earth's position, relative to the sun, during July. (The earth, as always, is tilted on its axis.) We can immediately see that, because of the earth's curvature, rays *near* the equator strike more



[FIGURE 11]

[FIGURE 12 (ABOVE); FIGURE 13 (RIGHT)]


NORTHERN HEMISPHERE
EQUATOR
SOUTHERN HEMISPHERE
A
B
C
Parallel rays from the sun
July
April
Sun
October
January
A
NORTHERN HEMISPHERE
B
EQUATOR
SOUTHERN HEMISPHERE
C
Parallel rays from the sun

[FIGURE 14]

perpendicularly than do rays *far* from the equator. Since perpendicular sunlight is warmer than oblique sunlight, equatorial regions are, on the average, the warmest parts of our globe.

But just why is perpendicular sunlight warmer? Consider lines A, B, and C. All are the same length and represent equal distances on the earth's surface. Do the same number of rays strike each of these equal lines? Count and see. You'll find that more rays reach line B, which is struck by rays that are nearly perpendicular, than reach line A. *The more perpendicular the rays, the more of them strike the earth in a given space.* It happens that solar rays generate heat as well as light, so B is a warmer place than A (which indeed it is: it lies near the equator).

Now compare lines A and C, which are equally far from the equator. In July, the earth's *Northern* Hemisphere is tilted toward the sun. This tilt causes solar rays to strike the earth more perpendicularly in the Northern than in the Southern Hemisphere. As a result, a greater number of rays strike A than C. A is therefore warmer. July is summertime in the Northern Hemisphere, wintertime in the Southern.

Every year, the tilted earth completely revolves around the sun, as shown in the middle part of Figure 14. In January, the earth has moved to the side of the sun opposite from its July position. The earth doesn't change its tilt; so during January the *Southern* Hemisphere is tilted toward the sun and receives more nearly perpendicular rays. Summer has come, while in the Northern Hemisphere, winter has its turn. (See the bottom of Figure 14.)

What it all gets down to is this: we have seasons mostly because of the different angles at which the sun's rays strike different parts of the earth at different times of the year; but these differences are caused not by the sun but by three characteristics of the earth: it is a sphere, it is tilted, and it revolves around the sun.

LATITUDE IS ONLY A PARTIAL CLUE TO CLIMATE

The sun's rays are most perpendicular—and most closely crowded together—in the tropics. This is especially so along the imaginary line called the equator, which runs through the middle of the tropics. Generally, the farther we get from the equator, the sharper the angle at which the sun's rays strike and the colder the climate that we might expect. Seasons aside, this lowering of temperatures north and south of the equator is a rule that would always hold true *if* the earth's surface were perfectly smooth and if it consisted of a uniform substance, such as water. But the earth's surface is neither smooth nor uniform, and, as a result, the rule has many exceptions.

Altitude is responsible for some of the exceptions. On the average, temperatures drop about 3 1/2 degrees Fahrenheit (1.94 degrees Celsius) for every 1,000-foot (305-m) increase in elevation. Mt. Kilamanjaro, Africa's highest mountain, is almost on the equator, yet its upper reaches are snow-covered throughout the year.

The presence of large bodies of water moderates temperatures. The tip of Long Island, 125 miles (200 km) "out to sea" from New York City, is almost completely surrounded by water. It is, on the average, warmer in winter and cooler in summer than New York City, though both are the same distance from the equator.

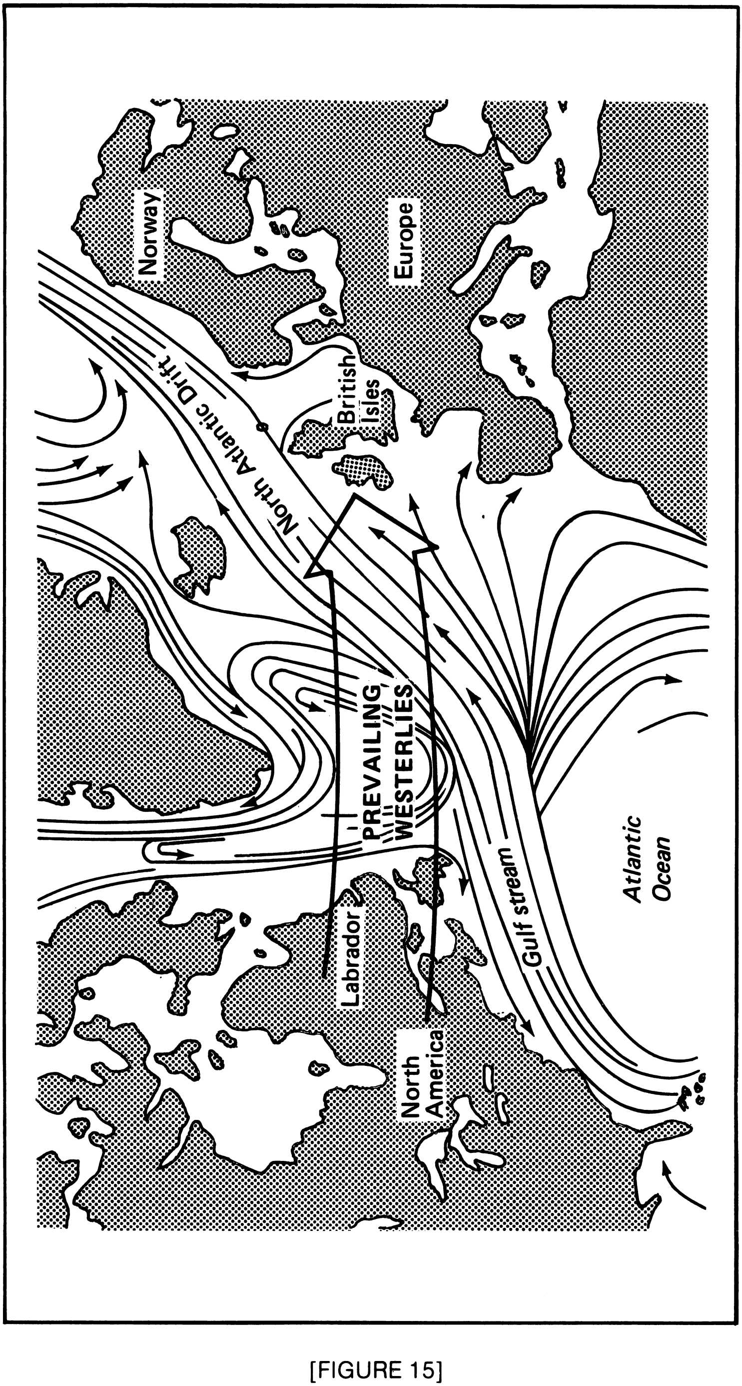
If distance from the equator—latitude—were all that mattered, the North and South Poles would be the coldest places on our planet. The South Pole, located in the interior of the ice-covered continent of Antarctica, is indeed the earth's "freezer." The North Pole, on the other hand, is located in the middle of the Arctic Ocean. Even though that ocean is largely ice-covered in the winter, the sea still manages to moderate the area's climate. As a result, the North Pole in winter isn't ordinarily as cold as some parts of

Canada and Russia that lie more than a thousand miles (1,600 km) south of the Pole but happen to be far from the influence of any large body of water.

One of the greatest influences on our climate is the combination of ocean and wind currents. For example, the Gulf Stream and its extension, the North Atlantic Drift, form a huge "river" of warm water that flows northward from the tropics right through part of the Atlantic Ocean. This great ocean current skirts the United States, the British Isles, and much of the west coast of continental Europe. The warmth of this stream heats the air immediately above it. At the latitudes where this takes place, the earth is crossed by wind currents that almost always sweep from west to east. (West-to-east winds are called westerlies; winds are designated by the direction they come *from*.) These prevailing westerlies pick up the air warmed by the North Atlantic Drift and carry it all over the British Isles and into the coastal areas of the European continent. The results are astonishing. (Figure 15.)

Take Ireland. It lies as far north of the equator as does Labrador, a cold and desolate part of Canada. Yet Ireland is green all the year except in its highlands, and, in the parts that are closest to the North Atlantic Drift, there are palm trees!

Then there's England. England lies as far north as Ireland. American visitors often complain about its cold weather; but England, like Ireland, really has a mild climate—relatively warm winters and relatively cool summers. What probably discomforts visitors are the typically damp, sunless days, combined with a scarcity of central heating. England's reputation as a very rainy part of the world is another widespread misconception. Rain does fall frequently in England, making the weather damp. But the rain is usually light, often just a drizzle, and it doesn't add up to anything unusual. London receives, in an average year,


Norway
Europe
British Isles
North Atlantic Drift
PREVAILING WESTERLIES
Labrador
North America
Gulf stream
Atlantic Ocean

[FIGURE 15]

about 23 inches (58 cm) of precipitation. Compare that with 40 inches (102 cm) for New York City, 32 inches (81 cm) for Chicago, 48 inches (122 cm) for Houston, and 14 inches (36 cm) for Los Angeles. And if you really want rain, consider Quillayute, Washington, with 105 inches (267 cm); Yakutat, Alaska, with 132 inches (335 cm); and Mt. Waialeale, Hawaii, with 460 inches (1,168 cm)!

Thanks to the North Atlantic Drift and the prevailing westerlies, many seaports above the Arctic Circle, in Norway, are usually free of ice throughout the year. In Iceland, that misnamed island nation in the far north, average temperatures at its capital, Reykjavik, are about the same as those of Philadelphia, Pennsylvania.

The combination of ocean and wind currents explains why Seattle, Washington, one of the northernmost cities in the United States, has mild winters and why there is surprisingly little variation in temperature along our west coast, from Seattle to southern California. West Coast temperatures are determined more by wind patterns and the offshore California Current than by latitude.

The Mediterranean Sea and its surroundings are famous for having a warm, sunny climate. Rome, the biggest city in the area, has mild weather most of the year. About how far south do you think Rome lies, compared with American cities? About as far south as Atlanta, perhaps? Or Miami? Or Los Angeles? Or Dallas? Actually, Rome is about the same latitude as Boston, one of the colder cities in the United States.

Earlier, we saw that during some months the earth's *Northern* Hemisphere is tilted toward the sun; other months, the *Southern* Hemisphere is tilted toward the sun. We also saw that when a hemisphere happens to be tilted toward the sun, it is having summer because it is receiving rays that are more nearly perpendicular than those striking the other hemisphere.

The tilt affects seasonal climate in other ways too. When a hemisphere happens to be tilted toward the sun, it receives not only a greater number of perpendicular rays but also more hours of sunlight each day. This means more daily hours of warmth, making that hemisphere warmer still. When the Northern Hemisphere is tilted toward the sun, the parts of Canada and Alaska that are north of the Arctic Circle have days when the sun never sets. Although they lie close to the North Pole, their temperatures often go above 90°F (32°C). There are plenty of flowers and butterflies, substantial vegetable crops, and reputedly the worst mosquitoes in the world!

4 Facts About the Moon and Outer Space

From earliest times, human beings have wondered about the moon. In trying to solve its mysteries, they have come up with explanations that are more myth than fact, for until recently they have not had the means to examine accurately a heavenly body 240,000 miles (384,000 km) away.

With the development of modern technology, astronomers have been able to uncover a great deal of solid information about this faraway place (which is, nonetheless, our nearest neighbor in space). They have studied the lunar landscape with giant telescopes and other sophisticated instruments. Astronauts have walked on the moon's surface.

Yet misinformation persists. Some astronomers have been heard to say that of the many myths about the moon, there are only two that are no longer widely accepted: one is that the moon actually changes its shape from day to day; the other is that it is made of green cheese.

THE MOON DOES NOT HAVE A DARK SIDE

Writers and orators frequently refer to "the dark side of the moon" when they want to suggest something that's forever beyond our sight or grasp. It's a nice sounding metaphor; but, in truth, there is *no* part of the moon's surface that is perpetually dark.

As with our own planet, earth, the side of the moon that is away from the sun at any given moment, is dark. But, in the course of a month, every part of the moon is exposed to the sun and has daylight.

What *is* true, however, is that the same *side* of the moon always faces the earth; the other side is always hidden from our view (unless we're an astronaut circling the moon).

THE MOON IS OUT IN THE DAYTIME AS MUCH AS IN THE NIGHTTIME

We think of the moon as a nighttime planet. When it is in the sky on a clear night, it dominates the heavens.

But would you believe that, during the course of a year, the moon is in our sky the same number of hours during daytime as during the night? It's there, all right; but ordinarily we don't notice it, for the daytime moon is but a small, pale spot in a big, bright sky.

A good time to see the moon during the day is between 10 a.m. and 2 p.m. about a week after the full moon has appeared or about a week before the full moon arrives. When searching, keep in mind that the moon follows approximately the same path that the sun seems to take. So, if you're in the United States or any comparable part of the Northern Hemisphere, sweep the southern sky with your eyes, from east to west. If it's a clear day, you'll find it.

THE MOON'S "CHANGING SIZE" IS AN ILLUSION

Have you ever looked at a full moon as it hovers near the horizon? It seems so big! Yet later the same day, when it appears high in the sky, it seems puny. Why does the moon look so much larger when it's lying low? It hasn't changed size. And it hasn't come closer to us. The apparent difference is just an illusion.

Every so often, a scientist comes up with a "definitive" explanation of this illusion. But so far no one has convinced others that his or her explanation is correct.

THE MOON CIRCLES THE EARTH IN 27 1/3 DAYS? IN 29 1/2 DAYS? NOT AT ALL?

Some books tell us that the moon circles the earth in approximately 27 1/3 days. Other books (and sometimes the same book, but on another page) give the impression that the circuit takes approximately 29 1/2 days. Why the difference?

When describing the time it takes the moon to go around our planet, most writers measure the time that passes between one full moon and the next full moon (or between *any* phase of the moon and the next similar phase). This takes about 29 1/2 days. But, this is not the time it takes the moon to make one complete circle. That requires only about 27 1/3 days!

Confusing? Yes. But there is a good way to help us understand the situation. Consider the hands of a clock. At 12 o'clock, the minute hand is exactly on top of the hour hand; both are pointed to the 12. In exactly one hour—at 1 o'clock—the minute hand makes one complete 360-degree circle of the clock face and is back on the 12. Meanwhile, however, the hour hand has moved on; it has gone to the 1. The minute hand must travel for *five extra* minutes (and a trifle more) before it catches up with the hour hand and the two are together again, one exactly on top of the other.

It's somewhat the same with the moon and the earth. Starting, say, at the time of the full moon, the moon makes one complete 360-degree circle of the earth in about 27 1/3 days. But meanwhile, the earth, which is traveling about the sun, has moved on. It takes extra time—a total of about 29 1/2 days—before the moon catches up and viewers on the earth again see a full moon.

To summarize: the time from full moon to full moon is about 29 1/2 days. But the time it takes the moon to circle the earth is only about 27 1/3 days.

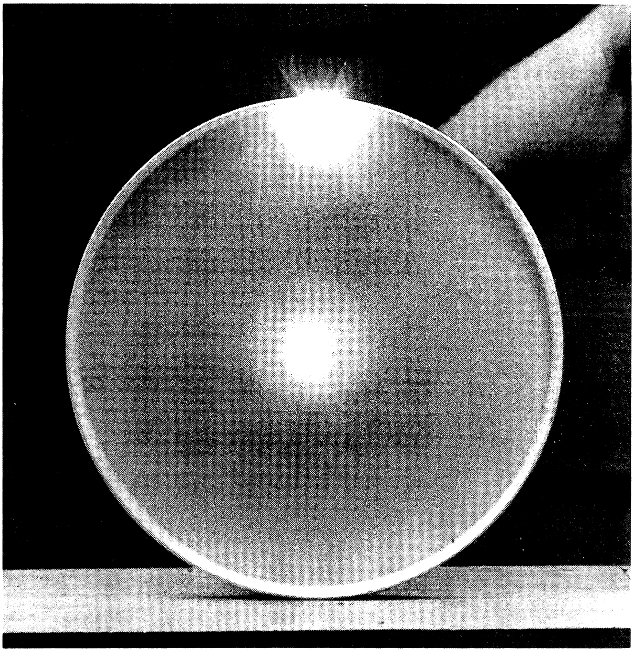
If you're a little confused about 27 1/3 days versus 29 1/2 days, here is the most mind-blowing, brain-boggling information of all: to someone looking on from far out in space, the moon doesn't seem to be circling the earth at all!

Here is a way of sneaking up on this preposterous idea so that we can better cope with it. Watch what happens to a wheel to which two small flashlights have been attached: one light at the hub (representing the earth), the other light near the rim (representing the moon). (Figure 16.)

If, in the dark, the wheel is rotated, with the hub remaining in place, a time-exposure photograph will show the outer lights making a circular path around the inner light, just as we might imagine the circular path the moon makes around the earth. (Figure 17.)

But, in reality, the earth does not stay in place as the moon moves around it; the earth, too, moves along. In Figure 18, the wheel is about to be rolled from left to right across a platform; the hub will be traveling, even as the outer light circles it. Now what will the path of the moon look like in a time exposure? The startling answer is seen in

FIGURE 16



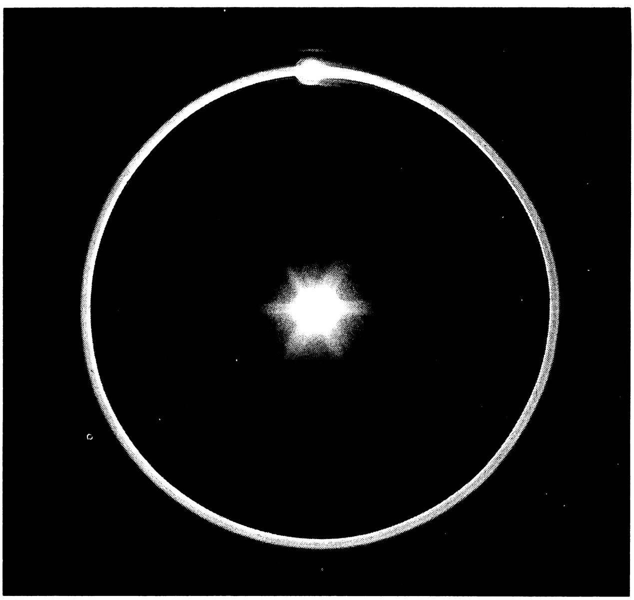


FIGURE 17

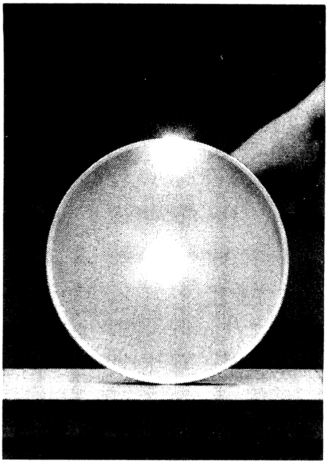


FIGURE 18

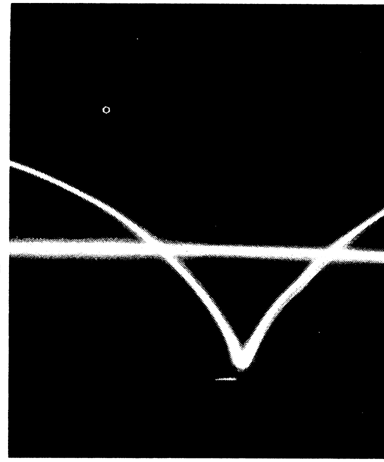
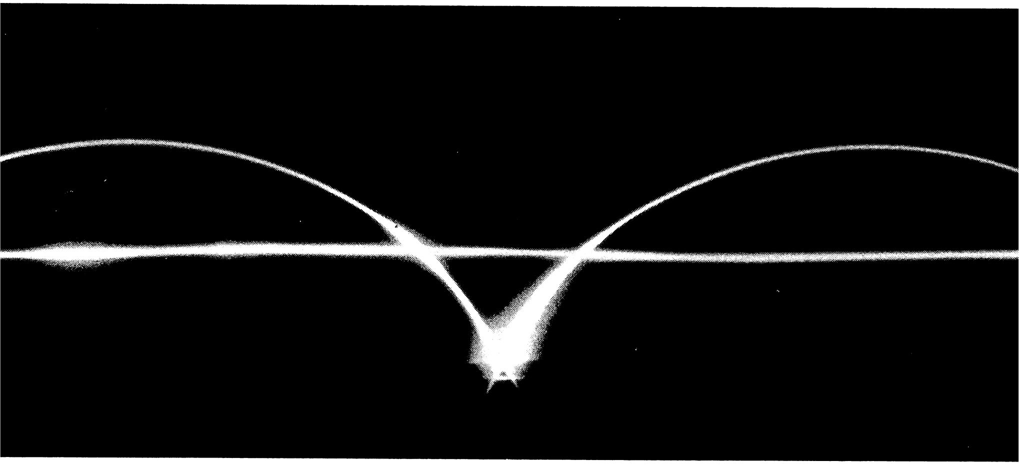


FIGURE 19

Figure 19. The "moon" has made a succession of scallop-like arcs. Nowhere does it appear to be circling the "earth."

The principle applying to the moon also applies to the path taken by the reflectors often attached to the spokes of bicycle wheels. However, the moon's path is much more complicated than that of a bicycle reflector or the flashlight in the above demonstration; still, a drawing of the moon's actual path (Figure 20) seems to indicate that it behaves essentially like that of the others: it does not appear to circle the earth!

There are science textbooks that flatly state that the circling of the earth by the moon is an illusion. On the other hand, the noted astronomer Lloyd Motz of Columbia University says this: "Despite the fact that the moon's path, when viewed from a distant point in space, does not form any obvious circles around our planet, the moon does indeed go around the earth, a fact that would be revealed by a moment-to-moment analysis of its movements."



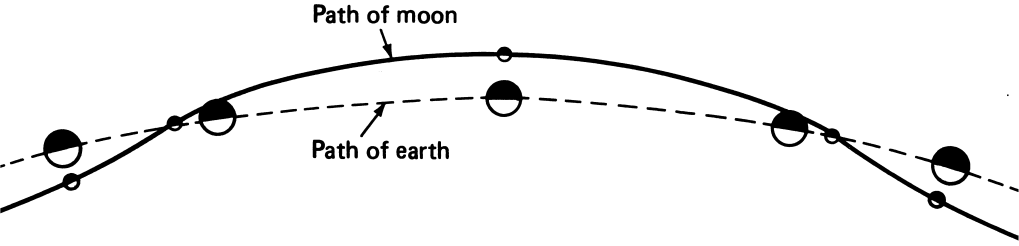


FIGURE 20

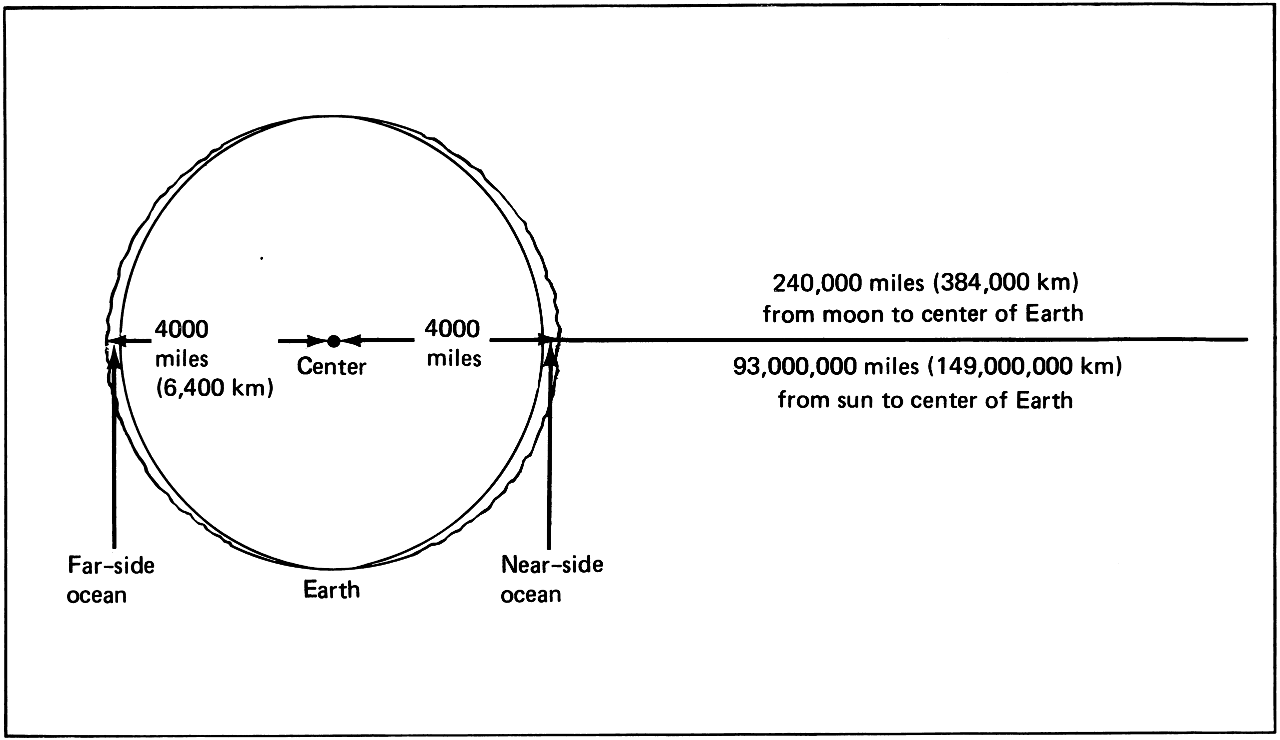
THE MOON AFFECTS OUR TIDES MORE THAN THE SUN DOES, BUT NOT BECAUSE ITS GRAVITY PULLS HARDER ON THE EARTH

Both the moon and the sun are responsible for our tides, with the moon having the greater effect. Typical explanations of the relative roles of the moon and the sun usually imply, or state outright, that the moon has the greater influence because it's closer to the earth, and therefore its gravity pulls harder. Wrong!

It is true that the force of gravity diminishes rapidly as distances increase and that the moon is much closer to us than the sun is—about 240,000 miles (384,000 km) compared with about 93,000,000 miles (149,000,000 km). However, the sun's gravitational force is so powerful that, despite the greater distance it must travel, it pulls much harder on the earth than does the moon's gravity.

To understand the following explanation of why the moon nonetheless has more effect, keep referring to Figure 21. First consider the role of the moon, alone. As the earth rotates, one area of the ocean after another passes nearest the moon in the course of a day. At any one moment, the nearest area is 4,000 miles (6,400 km) closer to the moon than is the solid earth. (The moon pulls on the solid earth as if all of the solid part were concentrated at its very center—a point about 4,000 miles beneath its surface.)

The moon's gravity must travel about 236,000 miles (377,600 km) to reach the near-side ocean but must travel 4,000 miles (6,400 km) more—a total of about 240,000 miles (384,000 km)—to reach the solid earth. Since the distance to the ocean is shorter, the moon pulls harder on the ocean and partially lifts it from the solid earth, forming a high-tide bulge.


240,000 miles (384,000 km)
from moon to center of Earth
93,000,000 miles (149,000,000 km)
from sun to center of Earth
4000
miles
(6,400 km)
Center
4000
miles
Far-side
ocean
Earth
Near-side
ocean

[FIGURE 21]

The point to remember is this: a tide is caused not by the amount of gravity involved but by the *difference* in the pull exerted on the nearby ocean compared to the pull exerted on the solid earth.

The solid earth, though 4,000 miles (6,400 km) farther from the moon than is the near-side ocean, is 4,000 miles *closer* to the moon than is the *far-side* ocean. Since the solid earth is closer, the moon's gravity is, in a sense, pulling the solid earth out from under the far-side ocean, causing a bulge there.

So we have two high tides a day—one where the ocean is nearest the moon, the other where the ocean is farthest away. And, since the earth rotates once a day, any particular place in the ocean will have two high tides a day—once when the place is nearest to the moon and once again, approximately a half-day later, when the place is farthest from the moon. (For clarity, the preceding details have been greatly simplified.)

Now for the role of the sun.

The sun's gravity creates tides in the earth's oceans because, like the moon's gravity, it travels 4,000 miles (6,400 km) less to reach the ocean than to reach the solid earth.

Although the 4,000-mile differential is the same for the sun as for the moon, the difference is *relatively* less significant. Four thousand miles means much less across 93,000,000 miles (149,000,000 km) than across 240,000 miles (384,000 km). The sun pulls harder on our oceans than the moon does; but when the pull on our oceans is compared with the pull on our solid earth, the moon's gravity is relatively greater. And it's relativity that rules the tides.

The height of tides is not the same from day to day. When the sun and moon are both in line with the earth, the effects of their gravities are combined and the tides are highest.

These "spring" tides occur approximately twice a month, once when the sun and moon are in line with the earth, but on opposite sides of our planet, and once when they are both on the same side of it.

When the sun and moon are at right angles relative to the earth, their gravities are working against each other, and the high tides are at their lowest. These "neap" tides also occur approximately twice a month.

So much for real tides. Now for a phenomenon that's generally called a tide, but really isn't.

Tidal waves, which are among the most destructive of natural events, have nothing to do with tides. Tides are caused by the gravitational pull of the moon and sun; tidal waves, on the other hand, are the result of earthquakes or volcanic eruptions occurring on or under the floor of the sea. The disruption sets off a racing surge of water that can travel thousands of miles. The waves can scarcely be noticed as they pass through deep seas, but when they reach the shallow approaches to a shore, they become mountainous walls of water.

Since tidal waves are improperly named, scientists prefer to call them by their Japanese term: *tsunamis.*

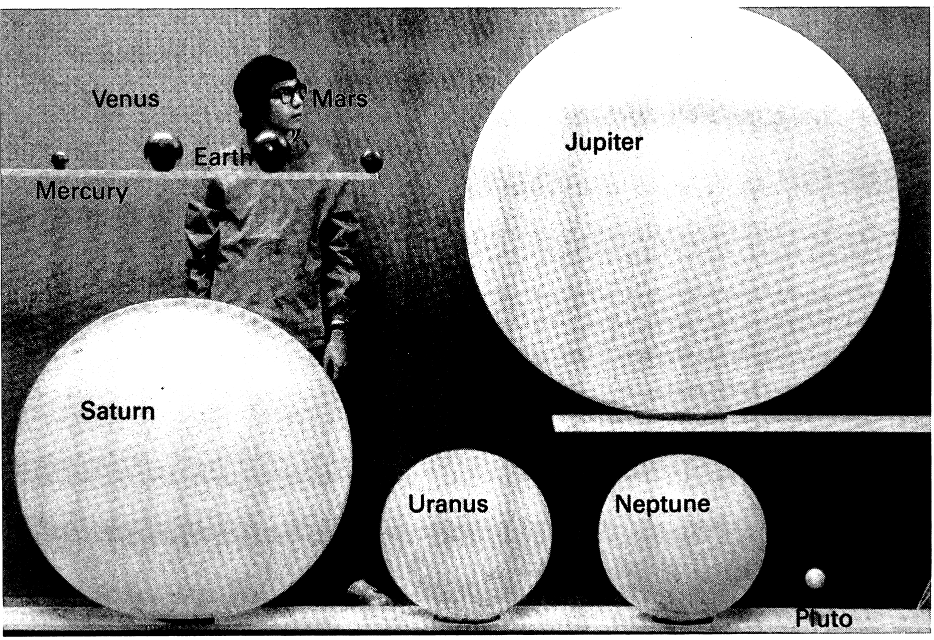
DIAGRAMS OF THE SOLAR SYSTEM DON'T DEPICT ITS TRUE SIZE

The solar system occupies only a small part of the universe, yet it is so gigantic that it is almost impossible to visualize its true size. Many books and newspapers have diagrams that try to give us a meaningful picture, but with limited success.

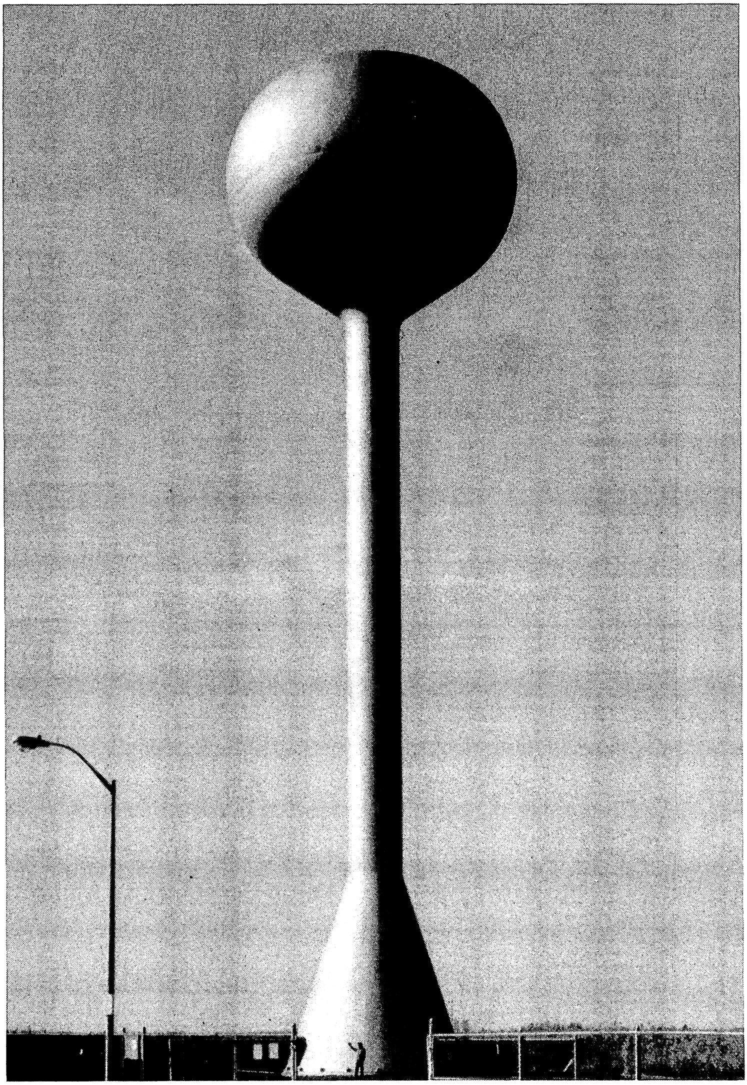
Diagrams of the solar system are unavoidably misleading because the paper on which they are printed is never big enough to do the job. If the earth's moon were shown the size of this letter—"o"—then the sun, to be in the same scale, would have to measure about 30 inches (76 cm) in diameter, which is more than twice the combined width of the two pages in front of you. And that's not even the main problem.

Keeping to the same scale, you'd need a piece of paper more than a quarter of a mile (.4 km) long in order to show the relative distances among all the known planets! To show the *orbits* of the planets, you'd need paper twice that size, both in length and width.

Here's a way that does show the solar system to scale: imagine that the balls and balloons in Figure 22 represent the planets in approximately their correct relative sizes. The ball with the white dot is the earth.

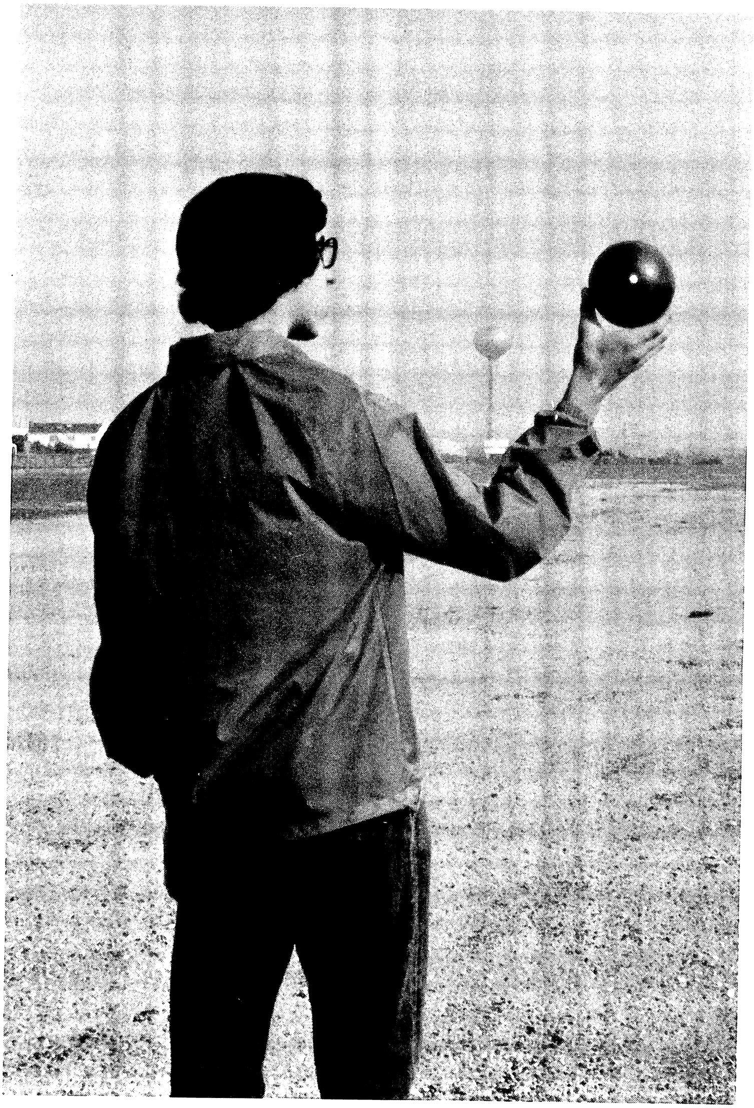


[FIGURE 22 (ABOVE); FIGURE 23 (RIGHT)]

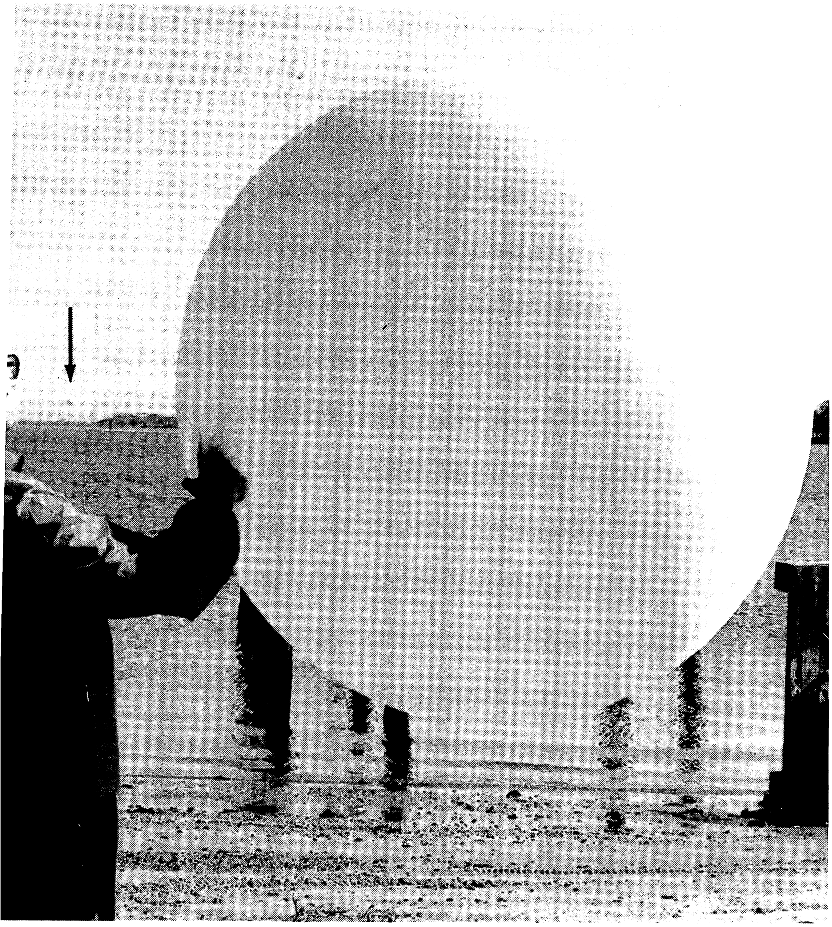


In Figure 23 imagine that the sphere on top of the water tower represents the sun, at the same scale used for the planets. (The speck at the base of the tower is the boy holding the earth.)

To show the distance between the earth and the sun at the same scale, the boy would have to carry the ball nearly *one mile* (1.6 km) from the tower! (Figure 24.)



[FIGURE 24 (ABOVE); FIGURE 25 (RIGHT)]



Jupiter, the largest of the planets, would—at the same scale—have to be carried 4½ miles (7.2 km) from the tower, which can now barely be seen. (Figure 25.)

Pluto, the most distant known planet, would have to be carried about 35 miles (56 km) from the tower! Pluto is about 3 1/2 billion miles (5.6 billion km) from the sun. But just think: despite that incredible distance, the sun's gravity holds Pluto in orbit.

The next time you see a diagram of the solar system contained on a half page of a book, pause for a moment and remind yourself of its true, staggeringly large dimensions.

SHOOTING STARS ARE NOT STARS

The solar system contains many small bodies that speed about in outer space. Among the smallest are meteoroids. Frequently, a meteoroid penetrates the earth's atmosphere, striking the air with such speed that the resulting friction burns it up. Most meteoroids are no larger than a grain of sand; they burn up completely in less than a second, with a sudden, bright flare. When they do burn, their name changes to *meteor* or, more popularly, "shooting star."

Of course, they are not stars. Stars are huge. Our sun is a star, a star of only average size. If a true star came within a million miles of us... zap! We'd have had it.

Some meteors are sufficiently large that they don't burn up entirely but crash onto the earth. A few have blasted pits more than a mile (1.6 km) wide. When they do manage to reach the earth, their name changes once more, this time to *meteorite*. Meteorites, which look like large, pock-marked nuggets of metal, can be seen in many science museums.

A ROCKET MOVES BECAUSE ITS JET OF GAS IS *NOT* PUSHING

A rocket is the only kind of propulsion engine that can be used in outer space. Propulsion engines get their energy from the burning of fuel, and burning requires the presence of oxygen. There is no oxygen in outer space. Rockets alone solve this problem by carrying their own supply.

It is widely believed that rockets get their push from the jets of gas that whoosh from their nozzles. Indirectly, that's true.

But it is more accurate to say that a rocket moves because the jet does *not* push! To begin to understand what this means, consider a toy balloon that's been inflated and its nozzle tied.

The balloon's rubber walls squeeze, or compress, the air that is inside. In turn, the compressed air pushes outward against the balloon walls. This pressure doesn't move the balloon because every push in one direction is countered by a push in the opposite direction. The push on the left wall is countered by the push on the right; the push on the front wall is countered by the push on the back (where the tied nozzle is located). No side wins out. All is in a state of balance.

But if the nozzle is opened, the push on the front is no longer countered by the push on the rear; instead of pushing, the compressed air rushes out the open nozzle. The push on the front wins and, instantly, the balloon flies forward.

It goes forward because the jet of air escaping out the rear is *not* pushing.

Here's a demonstration that indicates what happens both to the balloon and to a rocket engine. Get a mason jar. Cut away a small segment of the outer ring of the lid. Then close this gap by gluing a strip of paper across it. (Figure 26.)

Place the ring on a large ball, such as a basketball, and fill the ring with marbles, making sure that some of the marbles are under the lip of the ring so that the ring is raised off the surface of the ball. The ring, now riding on marbles, can easily roll in any direction; but, with care, you can get the contraption to balance on top of the ball. (Figure 27.)

FIGURE 26

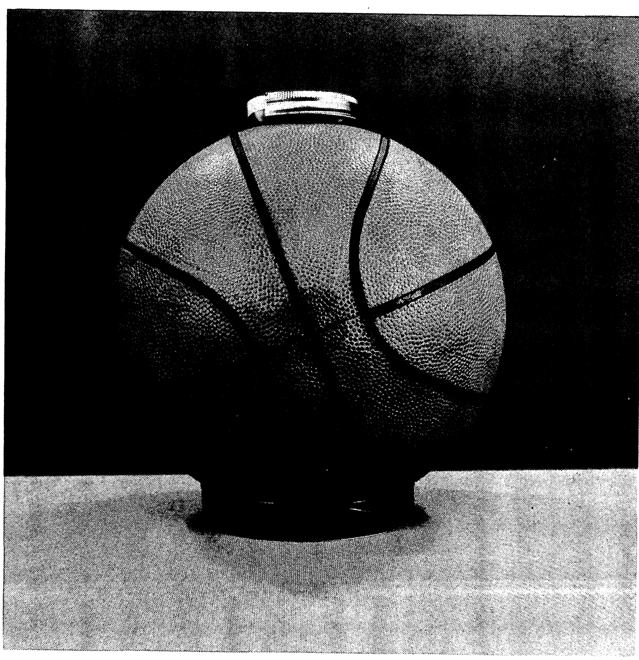


FIGURE 27

FIGURE 28

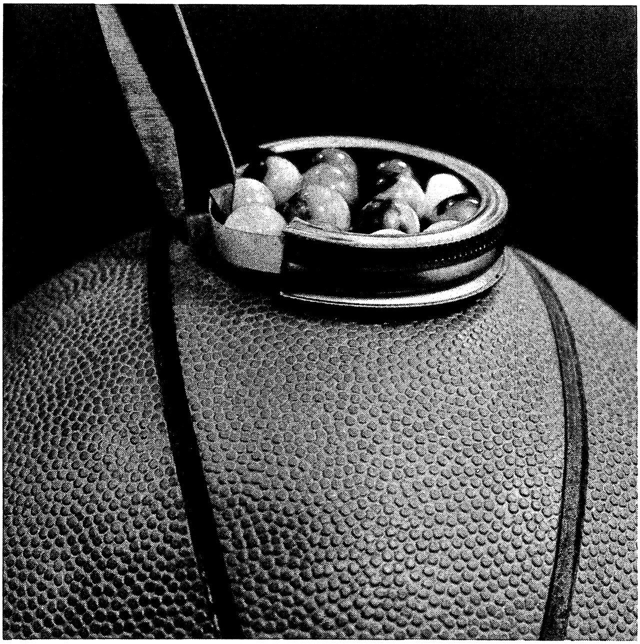
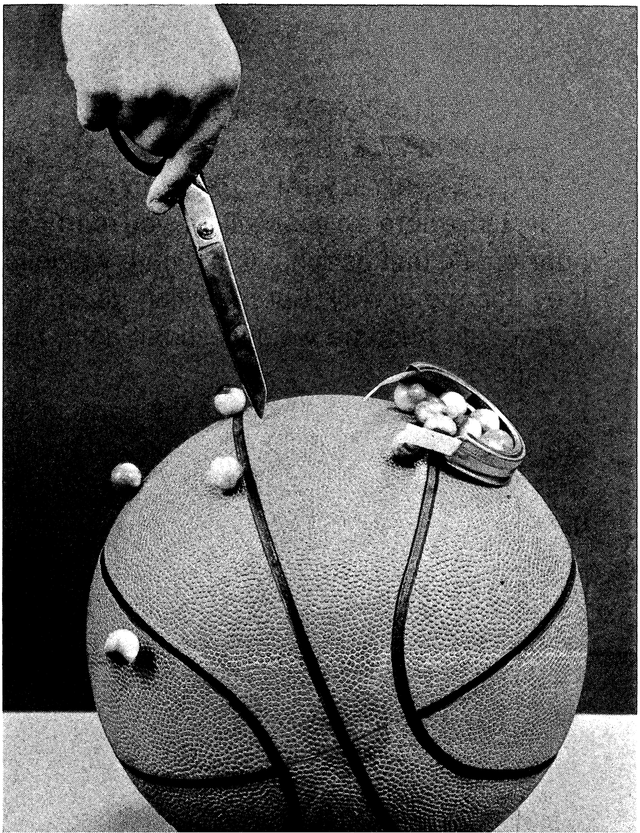


FIGURE 29



Gravity is tugging at the marbles. They would roll down the sides of the ball were they not held back by the walls of the ring. The ring itself would roll off the ball were the marbles not in a state of balance: the push by a marble against a wall of the ring is countered by the push in the opposite direction by a marble on the other side.

What will happen if you then carefully cut the paper? (Figure 28.) The marbles on the cut side no longer push against the ring. The push of the marbles on the opposite side wins, and the ring instantly moves in that direction. (Figure 29.)

In a rocket engine, fuel burns and turns into gas that, because of the great heat, expands with tremendous force. If there were no nozzle, the engine would—if it didn't explode—go nowhere; the pressure on any wall of the engine would be countered by an opposite pressure. With a nozzle at the rear, the expanding gas doesn't push at that point but, instead, rushes out. The push on the opposite wall wins and thrusts the rocket forward.

ASTRONAUTS BECOME WEIGHTLESS IN OUTER SPACE, BUT NOT BECAUSE THEY ESCAPE GRAVITY

Every time there's a space flight, you read in the press and hear on TV that astronauts become weightless because they escape gravity. But repetition doesn't make it right. Astronauts become weightless, all right, but they never escape gravity.

Spaceships usually circle the earth in an orbit about 200 miles (320 km) high. The ships and their contents are weightless, but this couldn't possibly be due to their having escaped gravity.

After all, the moon is about 240,000 miles (384,000 km) high, yet it is kept in orbit by the earth's gravity. What's a mere 200 miles (320 km)?

To understand weightlessness, we must first think about *weight*. We normally experience weight when our bodies, pulled downward by gravity, are resisted by the ground or a floor or anything else that prevents us from falling toward the center of the earth. We can feel this resistance. And if we step on a scale, we can measure it; the scale tells us how much weight the scale is resisting as our bodies push down on it.

In a spaceship, an astronaut's body, pulled by gravity, is resisted by his or her chair (which is resisted by the cabin, and so on). Before the rockets begin to fire, his or her weight is normal. But as the rockets blast off and keep pushing the ship at faster and faster speeds, they cause the chair to push harder and harder against the astronaut, which amounts to the astronaut's being pushed harder and harder against the chair. The astronaut feels heavier and heavier and, literally, *becomes* heavier.

It isn't the speed itself that matters as much as it is the *rate* at which the speed increases—the *acceleration*. The spaceship's acceleration must be moderate; if it reached its ultimate speed too quickly, the astronaut's weight would become so great that, among other things, his or her blood would become too heavy for the heart to pump. And even if still living, the astronaut would become too heavy to get out of the chair. If a spaceship were shot from a cannon, as was supposed to have happened in Jules Verne's book, *From the Earth to the Moon*, the too-rapid acceleration would quickly kill everyone in it.

To visualize what happens to an astronaut during a regular take-off, imagine that the postage scale in Figure 30 is a spaceship, with the scale's platform serving as an astronaut's chair. The 4-ounce (172-g) block of wood taped to the platform represents an astronaut strapped to a chair. Also pretend that the human arm holding the assembly is a rocket engine.

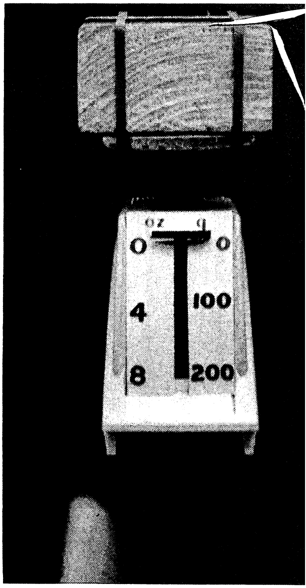


FIGURE 32

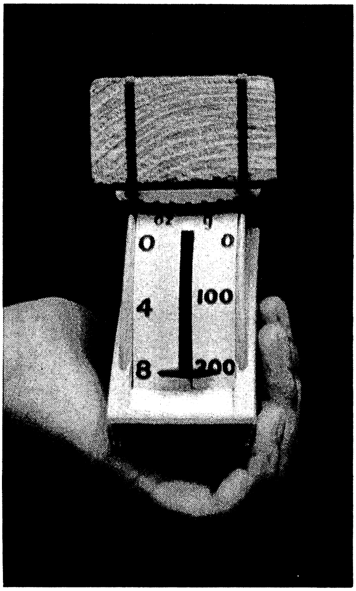


FIGURE 31

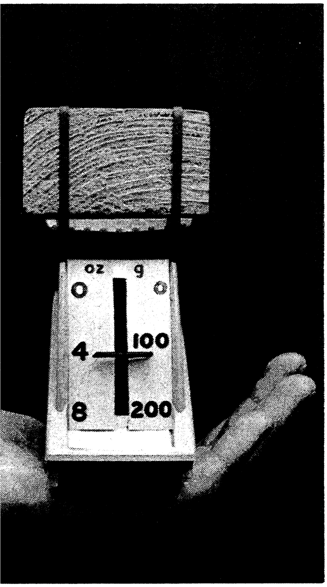


FIGURE 30

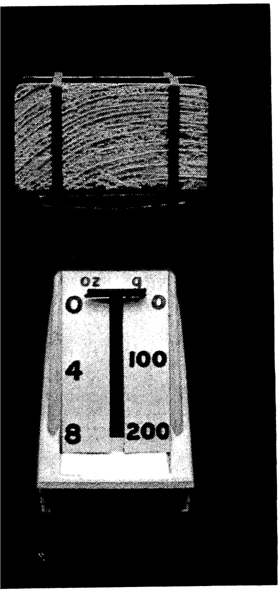


FIGURE 33

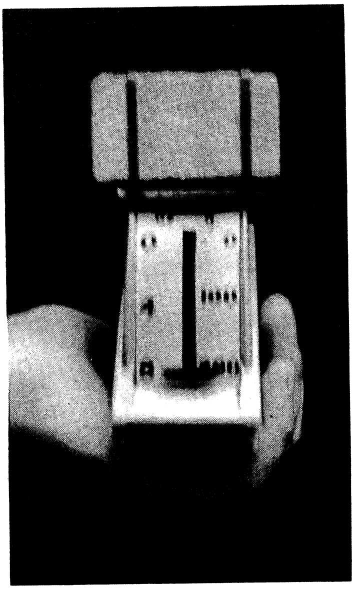


FIGURE 34

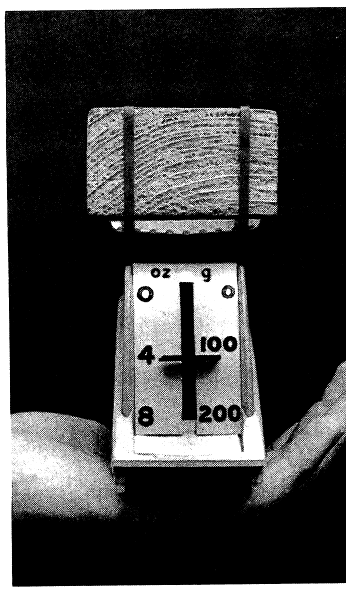


FIGURE 35

When the arm "fires" by jerking the "spaceship" upward (Figure 31), the "ship" and "chair" accelerate, and the "astronaut's" weight increases in this example to eight ounces (224 g). The more sudden the jerk, the more the weight increases.

The instant the "rocket" stops firing, the "spaceship" and everything in or on it are no longer being pushed. They all continue upward under their own momentum. Though they are now moving independently of each other, they remain together because they each received the identical final push. (The astronaut and the wood block would stay together even if they weren't tied down; they're tied to prevent their being accidentally shifted to the side.)

Since the "astronaut" is not being pushed, but is coasting along on its own, it is *weightless*—its weight drops to zero. (In fact, the scale reads slightly less than zero because the zero point was calibrated to allow for the weight of the scale's platform, which is itself now weightless.) (Figure 32.)

If an astronaut in a spaceship had a glass of water, the glass and every molecule of water in it would also be coasting upward independently and would be weightless. If the glass were gently turned upside down, the water wouldn't spill out because it would be moving on its own in the same direction and at the same speed as would everything around it.

An astronaut stepping outside the spaceship would not fall to earth. He or she, along with the spaceship, would continue coasting upward, side by side, at, say, 15,000 miles (24,000 km) per hour. Since there is no air in space to rush by him and since the spaceship remains at his side, he would have little sense of motion.

Just as soon as its rockets stop firing and the spaceship starts coasting, gravity starts to slow it down. Eventually, it starts falling to earth, along with everything in or on it. Gravity pulls equally on all objects regardless of their size and weight (and disallowing interference from air). So the spaceship and the astronaut fall at the same rate, as does the postage scale and the wood block (in this instance, air interference is negligible). Therefore the block still is not pressing against the scale; it continues to be weightless. (Figure 33.)

When a falling spaceship reaches the earth's atmosphere, it bumps into the air and slows down. It is further slowed by parachutes and, eventually, by the earth's surface.

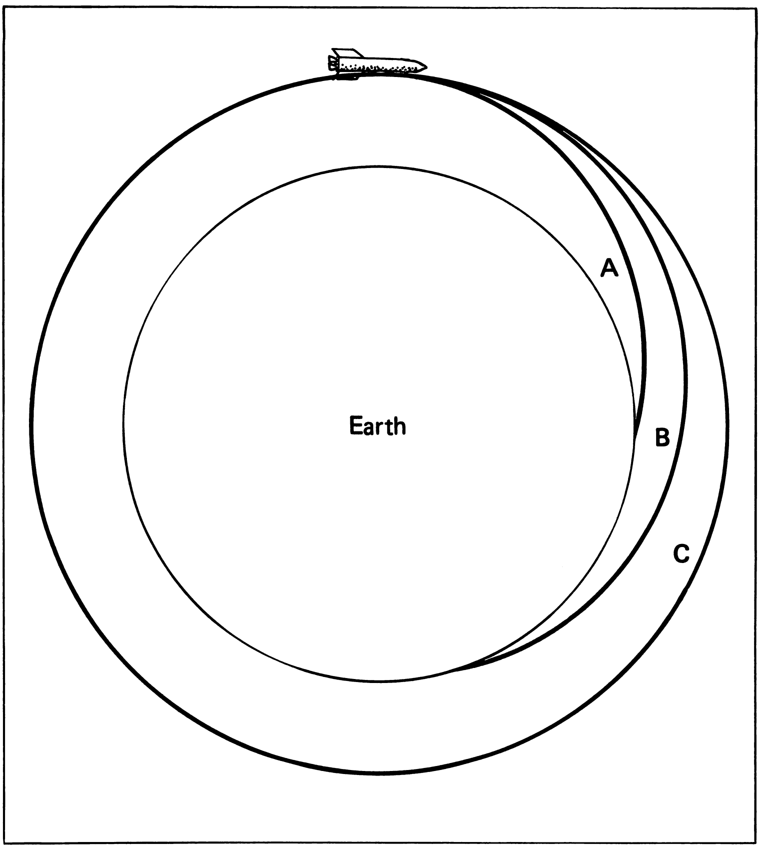
The astronaut, who had been falling freely, suddenly presses onto the slowed-down chair. He or she becomes heavy again. The more rapid the slowdown (Figure 34), the heavier he or she becomes, until the spaceship finally stops and his normal weight returns (Figure 35).

Under certain circumstances, a spaceship need not ever be pulled back to earth, despite the persistent pull of gravity. Even though its rockets may be exhausted, it can coast indefinitely.

One such circumstance occurs if a rising rocket reaches a speed in excess of 25,000 miles (40,000 km) per hour before it stops firing. Once the firing stops and the ship starts to coast, it will be slowed down by gravity. But because of its fast start, it quickly rises from the surface of the earth; and the farther it gets, the weaker gravity becomes.

Eventually, the spaceship's speed may drop to a few hundred miles per hour or less; but by then it has reached a point so far from the earth that gravity is too weak to stop its upward movement. A 25,000 mile- (40,000-km-) per-hour start is the *escape velocity* for a spaceship near the earth's surface.

Another way for a spaceship to avoid falling to earth is by orbiting our planet. The ship must first be rocketed above the atmosphere so it can then be beyond interference from air. About 200 miles (320 km) is a typical orbital altitude. The ship must then be aimed parallel to that part of the earth that's below it and given a final blast from its rockets (Figure 36). If the final blast doesn't make the spaceship go fast enough, gravity will pull it down to earth along a curving path, such as A. If the blast is stronger and makes the ship go faster, but still not fast enough, gravity will pull it down in a curving path, such as B. If, however, the final blast is sufficient, the ship will fall along a curving path, C, that matches the curvature of the earth. The ship,



[FIGURE 36]

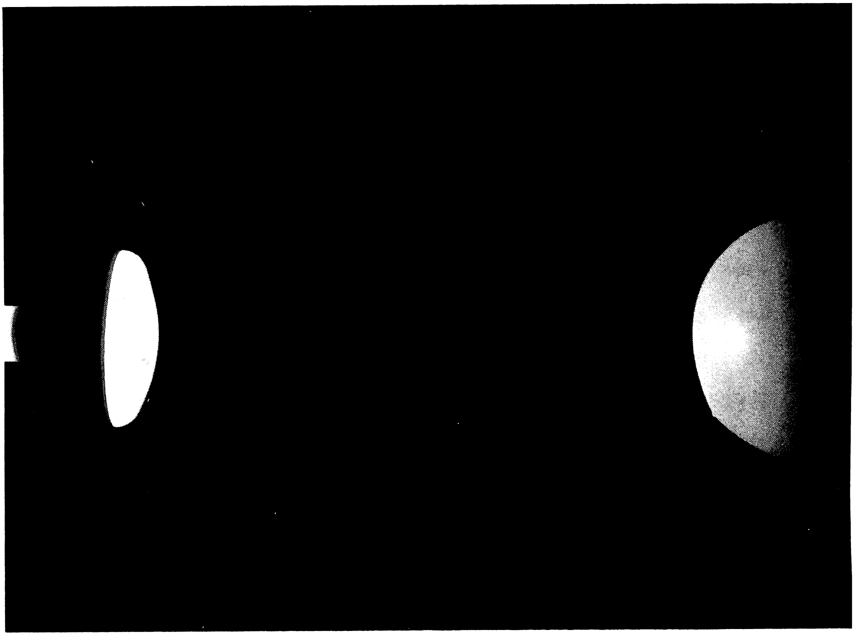
though constantly falling, would never hit the earth, for the earth's curved surface would be constantly falling away beneath it! If nothing further were done, the spaceship would keep falling around the earth, almost forever. It would become a satellite. And since gravity would be pulling down everything inside the ship at the same speed as it would be pulling down the ship itself, nothing would be pressing on anything, and everything would continue to be weightless.

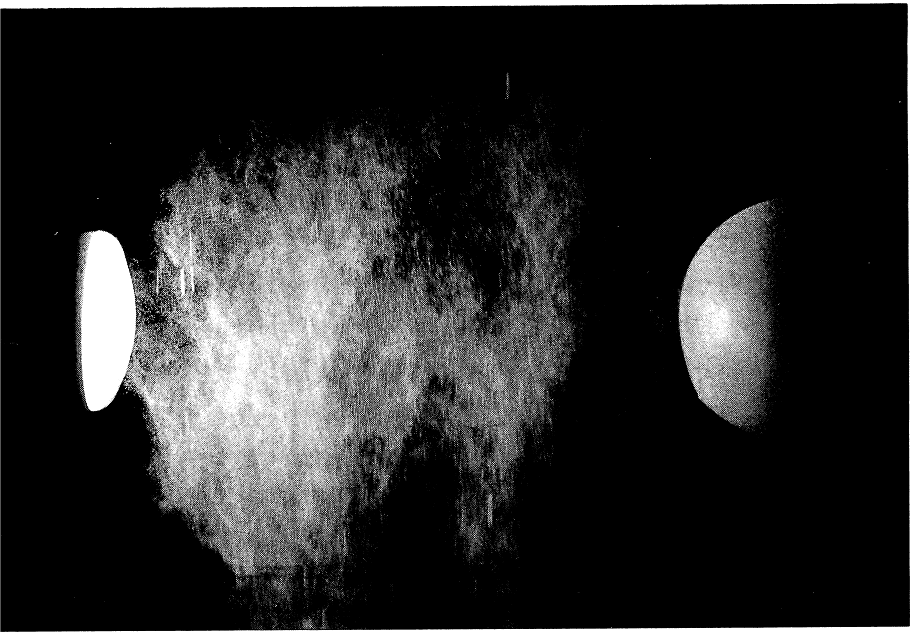
The right speed for orbiting depends on the height of the orbit; the higher the orbit, the weaker the gravity and the slower the speed required to keep the satellite on a correct path. A satellite 200 miles (320 km) up must orbit at slightly less than 18,000 miles (28,800 km) per hour. For the moon, which is a satellite that's about 240,000 miles (384,000 km) up, the orbital speed is only 2,000 miles (3,200 km) per hour.

At 22,000 miles (35,200 km) up, the orbital speed is such that a satellite makes exactly one revolution around the earth in one day—the same time it takes the earth to make one complete rotation around its axis. The result: the satellite hovers over the same spot on the earth and gives the illusion that it's motionless. Three communications satellites placed at 22,000 miles (35,200 km) and spaced the right distances apart could blanket every place on earth with their signals.

OUTER SPACE IS BLACK

Outer space is flooded with rays from the sun and from billions of stars and planets. We might reasonably expect it to be brilliantly lit. But it isn't, for the rays are, in themselves, invisible. They become visible only if they reach our eyes and are interpreted by our brain. This can occur only when we look at an object that is emitting rays. We cannot see rays that are just passing by.





[FIGURE 37 (ABOVE); FIGURE 38 (BELOW)]

Let's say that we placed a balloon outdoors on a dark, dustless night and shined a light on it. We'd see the light of the bulb if we looked directly at the bulb. And we'd see the light reflected from the balloon if we looked directly at the balloon. But if we looked *between* them (Figure 37), we would not see the rays that were traveling from the flashlight to the ball. The area would appear black.

If we then scattered chalk dust or powder into the area, the traveling rays would bounce off the chalk particles and enter our eyes. The area would appear to have daylight. (Figure 38.)

We see daylight on the earth because the atmosphere has particles that reflect the sun's rays into our eyes.

The moon, unlike the earth, has no atmosphere. During its daytime, astronauts on its surface can see the moon's ground because it reflects the sun's rays into their eyes. But there are no atmospheric particles to reflect the rays passing through the moon's sky; so the rays go right by, and the sky appears black.

It's the same throughout outer space. It is full of light rays but the only ones visible are those that enter an observer's eyes when looking directly at the sun or other bodies. In the vast and virtually empty spaces in between, the rays are passing by, invisibly, and there is only blackness.

Facts About 5 Primary Colors

Here's a single item that gets a chapter all to itself, because it is so controversial.

In the research that preceded the writing of this book, primary colors, of all the subjects covered, proved to be not only the one that was the most widely misunderstood but also the one that people most often refused to change their minds about. If a person had allegiance to the traditional version of what constitutes the primary colors, he or she usually defended that position vigorously, often angrily. All this despite the fact that everywhere—in photography, in TV, in printing—the correct rather than the incorrect theory of primary colors is constantly being applied.

From our earliest years in school, practically every one of us has been taught that the primary colors—the basic colors from which all colors can be made—are red, yellow, and blue. This definition is taken for granted by teachers, artists, decorators, in fact by almost everybody. And it's reinforced by the practical results that so many practitioners seem to get when they mix those colors.

In spite of all this, the primary colors actually *are red*, blue, and green. *Green*, not yellow!

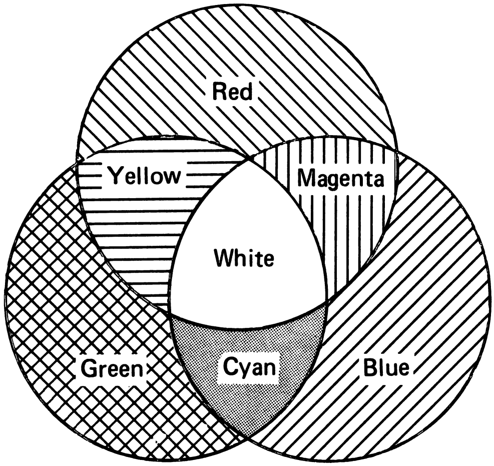
Virtually every scientist involved with color agrees that the primaries are red, blue, and green. Engineers and inventors who design precision color devices agree with the scientists. They have created color photography, basing it on red-blue-green theory; with these primaries, photographic film reproduces all the hues of the rainbow. The same is true with color TV; each tube contains three projector guns—one red, one blue, one green—that together show the entire spectrum of colors.

Scientists who specialize in the human eye say that there are three sets of eye nerves that receive color stimuli: one set receives only red light waves, one receives only blue, and one receives only green. When light waves from a colored object enter the eye, those nerves extract, respectively, the red, the blue, and the green. The brain then combines them so that the viewer sees the object with its original color values.

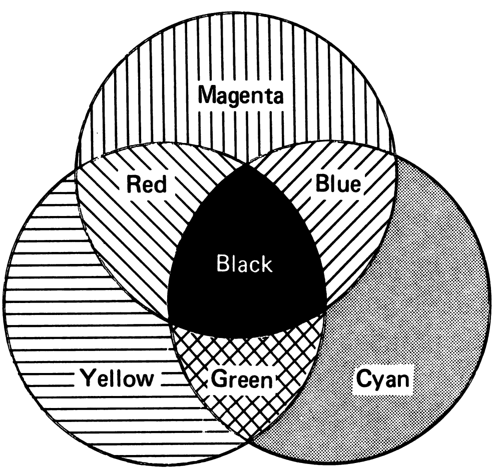
So far, we've mentioned primaries in connection with photo film, TV tubes, and human eyes. Each of these is concerned with colored *light*, not with colored paints, pigments, inks, dyes, or other *colorants*. When working with colorants, the "working" primaries are the "opposites," or *complements*, of the true primaries. The complements are magenta, cyan, and yellow. Yellow at last!

In Figure 39 you get the whole story (insofar as it can be shown in black-and-white). The true primaries are red, blue, and green. When mixed in equal amounts, red and blue lights produce magenta (reddish-blue); blue and green lights produce cyan (bluish-green); and red and green lights produce yellow. The three primaries, mixed together, produce white.

Mixing two *colorant* "primaries" produces the colors indicated in the illustration. When all three are mixed, the



Primary colors



"Primary" colors for colorants

FIGURE 39

result, in theory, is black. In practice, the result is usually a muddy gray or brown. To get good blacks, printers run paper through their presses not just three times—using magenta, cyan, and yellow inks—but also a fourth time—using black ink. This process is known as "four-color printing."

The literature on primary colors can be confusing. Books by and for painters and decorators are almost always on the red-yellow-blue track and refer only to colorants rather than to light. The only books that are usually on the *right* track are those written for photography, TV, printing, and science audiences. A few less-professional books are correct, too. A good example, for young readers, is *The First Book of Color* (Franklin Watts). It says:

> The color-sensitive cones of the eyes are believed to be divided into three groups: red sensitive, green sensitive, and blue sensitive... The colors corresponding to cone sensitivity—primary red, primary blue, and primary green—are called *the primary colors of light*... In surface colorants such as paints, inks, and dyes, the fundamental colors are magenta, yellow, and cyan.

Those of you who depend heavily on dictionaries for authoritative information are in for a shock. One of the most highly regarded among them is so complex in its explanation as to be practically unintelligible. Among the others, a few give only the conventional (and completely wrong) red-yellow-blue theory. The majority correctly give red, blue, and green as the *light* primaries; but then, for the colorants, they fall back into the incorrect red-yellow-blue groove. There are only a couple of dictionaries, notably the one from American Heritage, that are in complete and unequivocal agreement with color scientists.

The traditional red-yellow-blue fallacy was undoubtedly established long ago, before we had precision instruments that could accurately analyze light waves and before we had color TV, color photography, color printing, and other media that demand exact measurements.

Back then, the emphasis was on colorants; there was little need to think about mixing light. When the mixing of paints and inks is all that matters, satisfactory results can be obtained by using almost any three colors as primaries, providing they are far apart from each other on the color spectrum. That's why red-yellow-blue, though unscientific, works well enough for artists. Furthermore, many people mistake magenta for red and cyan for blue (there's no mistaking yellow for anything but yellow). So, some artists may actually be using the correct colorant primaries—magenta, cyan, and yellow—when they think they're using red, yellow, and blue.

To the extent that scientists can be sure about anything, they're sure about the primary colors. And their conclusions are readily available, not only verbally but in the countless devices that utilize their knowledge. How devilishly fascinating, then, that their message has reached so few of us.

Conclusion

Now that we've sampled some of the false "facts" that clutter our storehouse of knowledge, perhaps you'd like to consider some of the possible reasons why we seem so susceptible to misinformation.

Is much of it ancient folklore that we learn as children and find difficult to shed?

Are we uninterested in challenging any information—especially scientific information—because we feel it is dull? Would most of us rather argue about the number of wives of a movie star than the number of our senses?

Are facts unimportant if they don't directly affect our welfare? Does knowing why astronauts become weightless benefit us socially or vocationally? Would the knowledge necessarily benefit even an astronaut? Maybe all he or she has to know is that he or she *is* weightless, not *why.*

We can derive so much pleasure from learning about the world around us. But how many of us get as much satisfaction about knowing why apple trees must be grafted as we get from knowing where to get the best buy in apples?

Is the truth often too difficult to find? And are we sometimes afraid of where the truth may lead? Isn't it easier to oversimplify or distort? "The moon rules the tides because it's closer to earth than the sun and therefore pulls harder." Now there's a neat and understandable explanation, even if it is a wrong one.

Is the search for truth really important to us? Or are we more concerned with mystical matters? No group of reputable scientists has ever found verifiable evidence to support astrology; yet, because of popular demand, about 1,300 of the nation's 1,700 daily newspapers have regular astrology features, complete with daily horoscopes. And the United States is believed to be supporting about 20,000 astrologers, but only 2,000 astronomers!

Or does this book present a cockeyed picture of our addiction to false "facts"?

What do you think?

Index

SCIENCE FACTS YOU WON'T BELIEVE

WILLIAM P. GOTTLIEB

Contrary to popular opinion, bats are not blind and compasses don't point to the North Pole. These are just two of the many common misconceptions shattered in *Science Facts You Won't Believe,* a book that will shake up your thinking and stimulate your interest in science.

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- The primary colors are not red, yellow, and blue.
- Owls cannot see in the dark.
- The moon does not circle the earth.
- There is only one ocean, not five.
- It snows more in Texas than at the South Pole.

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